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TITLE:

"Use of Performance Measures to Evaluate, Document Competence and Deterioration of Advanced Surgical Skills Exposure for Trauma (ASSET) Surgical Skills". The Title was abbreviated as Retention and Assessment of Surgical Performance (RASP)

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14. ABSTRACT To address the decline in training programs and practice in exposing major vascular structure to control traumatic hemorrhage, the American College of Surgeons introduced a cadaver-based course to review the necessary surgical anatomy, procedure, skills, and techniques for rapid vascular exposure. Preliminary analyses comparing surgical resident performance before and after training, surgeons trained 2-5 years ago, and expert surgeons indicates that the objective assessment tool and "Trauma Readiness Index" metric distinguish between skill level groups, identify improvement and degradation. Using the objective assessment tool, anatomical knowledge and surface landmarks significantly impacts the correct and successful procedural performance. This mobile task-based assessment tool has high inter-rater reliability and may also be used to evaluate skill remotely.					
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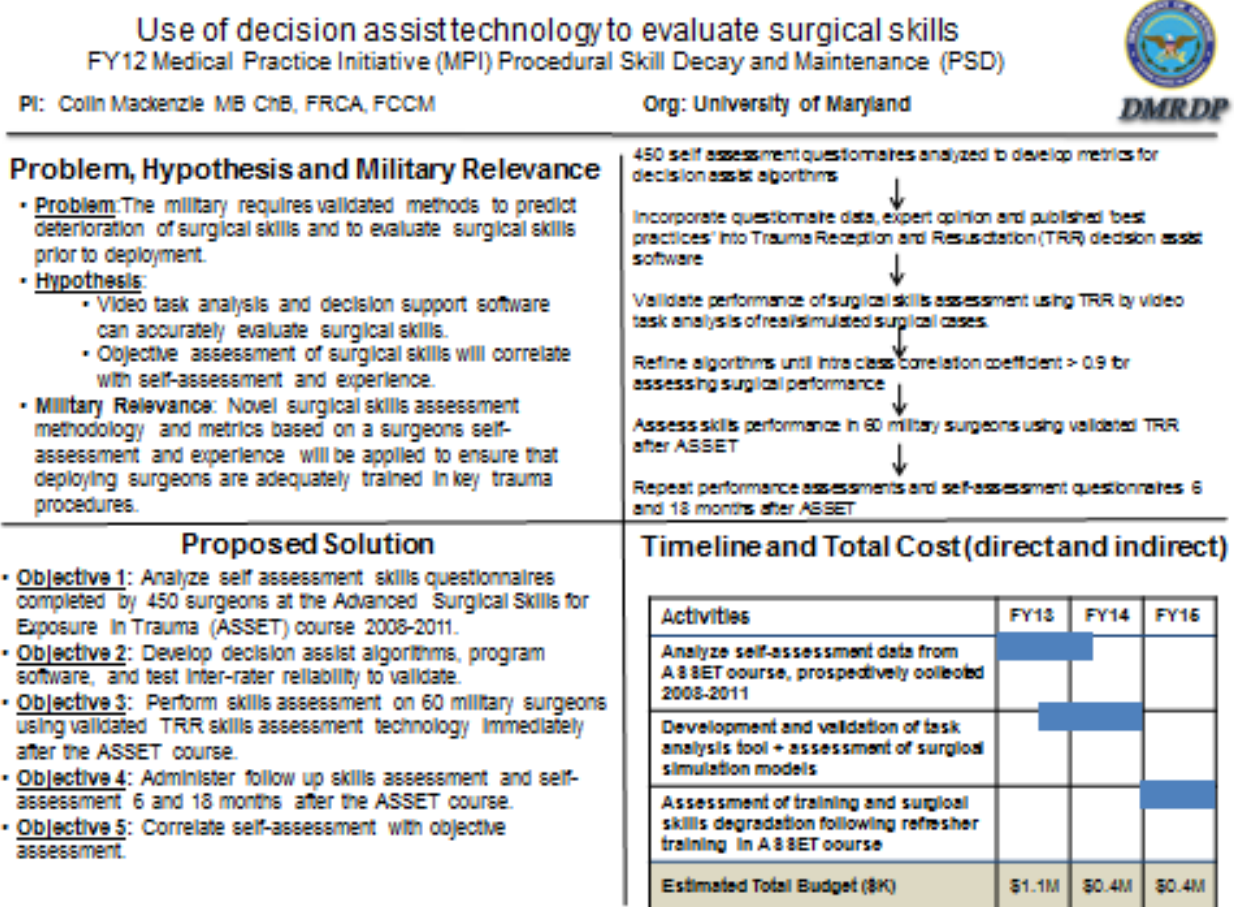
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Introduction

In cases of trauma, knowledge of major vasculature exposures is the primary step in gaining rapid control of hemorrhage. Bleeding is the leading cause of early death in military and civilian casualties, and both military and civilian trauma surgeons must maintain proficiency in the surgical exposure and control of major blood vessels. However, there has been a decreasing experience with vascular trauma among graduating surgical residents, thus the ability to objectively measure the acquisition, retention, and decay of surgical skills is crucial to training and maintaining casualty care teams. This project will demonstrate the utility of the Advanced Surgical Skills Exposures for Trauma (ASSET) course, developed by the American College of Surgeons Committee on Trauma, and assess, by developing performance assessment tools, the acquisition and retention of ASSET skills for 1- 5 years for upper and lower extremity hemorrhage control and lower extremity fasciotomy to provide critical insight into the duration and degradation of those skills over time. The process and procedures are summarized below.



Body

Statement of Work

Phase I – Preliminary investigations, TRR audit modification, and validation of Advanced Surgical Skills for Exposure in Trauma (ASSET) Performance testing methods

Task 1d) Audio-visual (AV) recording of “thinking out loud,” and responses to questions on technical and non-technical skills and fidelity of physical models vs cadaver during ASSET procedures by 10 expert surgeons and 10 surgeons without prior ASSET training, months 3-7. DFA: 210 days; AC: Completion AV recording and AV data collection synthesis; POC: 10%

- Completed in October 2013 but assessment of the Novice performance utilizing the technical and non-technical skills identified by the expert surgeons as important was presented as an abstract July 2014 at AMSUS (Society for Federated Health Professionals) in Dec 2014. The metrics distinguished Expert from Novice surgeons with excellent inter-rater reliability (Appendix 1).
- A single developed an index (Trauma Readiness Index) to quantify surgical performance and competence derived from knowledge, procedural, and technical skills components. Performance from Novice evaluations was assessed with this metric and results were presented at MHSRS (August 2014, see Appendix 2 for Presentation)
- To establish a “gold standard” range for expert performance suitable for comparisons with surgeons in later phases, it was necessary to assess 10 additional expert surgeons using the same skills assessment tool. To date, an additional 8 of 10 expert surgeons have been assessed and compared with Phase 2 and Phase 3 performance assessment data. These data provide a benchmark to compare the magnitude of skills performance improvement after training and degradation in the years following training (Appendix 3, Figure 1).

Task 1f) Modify TRR software to include these points, and conduct inter-rater reliability by multiple expert reviewers of ideal and non-ideal ASSET procedure performance, months 5-9. DFA: 270 days; AC: TRR Software modified and TRR Performance Audit tool validated; POC: 18%

- Major modifications of TRR software were accomplished by November 2013, but minor modifications were completed by April 2014 and the technology was implemented for evaluations 21 April 2014. A training module was developed for evaluators (Appendix 4)
- The mobile platform was described and presented at MHSRS in August 2014 (Appendix 5). This poster describes the head camera, pan/tilt/zoom camera, audio capture and Android software used for skills assessment.

Phase II: Using the revised and validated ASSET Testing tools developed in Phase I (as described in Task 1e), examine the efficacy of the ASSET training curriculum on acquisition and retention of

ASSET skills, including the relative efficacy of unpreserved cadaver versus selected non-live-tissue models in skills training.

- The relative efficacy of unpreserved cadaver versus selected non-live-tissue models in skills training was assessed using the attached questionnaire (Appendix 6). In addition another questionnaire was used to compare the unpreserved cadaver to a live patient (Appendix 7). These data are currently being analyzed and an abstract submitted for MHSRS (for 2015).
- Each surgeon was asked to rate their confidence for performing vascular surgery in the upper and lower extremities before and after each evaluation using the attached questionnaire (Appendix 8). These data were compiled and presented at ASC (Academic Surgical Congress in February 2015 and a manuscript submitted in January 2015) indicating that resident confidence in their ability to perform the 3 vascular procedures and lower extremity fasciotomy was significantly higher than their skills performance evaluations (Appendix 9).

Task 2a) *Train forty (in cohorts of 10) ASSET-untrained surgeons: test base-line skills, provide ASSET course, do post-test, months 10-17. DFA 510 days; AC: training and Phase 1 assessments complete; POC:15%*

- We completed enrollment, baseline before-training skills assessment, ASSET course training, and post-training assessments for 39 of the proposed 40 ASSET naïve surgical residents Sept 3 2014 (Figure 2). The final 40th resident will complete the post-training assessment by March 16 2015. A last minute enrollment drop-out necessitated this substitution and delay in completion.
- To date, five additional abstracts and two manuscripts have been completed detailing the assessment of surgical skills for before and after training co-located evaluations and remote video review. This includes a manuscript was accepted for publication in the Journal of Trauma detailing the performance evaluations before and after training (see Appendices 10 - 16)

Task 2b) *Mid-term review meeting with investigators and consultants - 2 days in month 18. DFA: 540 days; AC: meeting minutes and presentation materials as appropriate; POC: 1%*

- Midterm In Progress Review (IPR) was conducted August 2014 in Orlando Florida. The presentation slides and subject matter expert reviews are attached (Appendices 17 a & b)

Task 2c) *Forty surgeons from 2a) perform 4 ASSET procedures in random sequence on physical model and cadaver, months 11-18. DFA: 540 days; AC: assessments for physical model v cadaver; POC: 10%*

- see response to Task 2 a) above

Task 2d) *Reevaluate 2b/2c surgeons at either 12 (n=20) or 18 months (n=20) on physical model & cadaver. DFA: 990days; AC: TRR Performance Audit records and other performance assessments; POC: 15%*

- We are beginning to schedule these evaluations. Thus far, we have 8 of the 40 follow-up evaluations with confirmed scheduling between March – June 2015 and the first will occur March 23rd 2015.

Phase III: Examine various aspects of skills degradation over time, including comparison of skills degradation among 40 surgeons participating in past ASSET courses (cadaver model training only) and those participating in the study-based ASSET training curriculum.

Task 3a) Recall and retest previously ASSET-trained surgeons on cadaver at intervals of 2-5 years from original training, months 11-30. DFA: months 32-36 DFA; AC: Repeat ASSET procedures in 40 previously trained surgeons. Complete skills assessments as originally administered and TRR Performance Audit; POC: 15%

- We are currently scheduling and evaluating the ASSET course alumnae. Out of 40 proposed surgeons, trained 2 to 5 years ago, we have evaluated 11 and confirmed scheduling with an additional 7 for evaluation in March - June.
- Using this preliminary retention data, we are comparing the current skills levels of the ASSET alumnae to the 39 pre and post-training surgical resident and 8 expert scores. Three abstracts are being submitted for review to MHSRS for 2015 (Figure 1 & 3; Table 2).

Task 3b) Data analysis; draft paper and present results, 37 months DFA; AC: Final report acceptance; POC 1 %

Key Research accomplishments

- Initialized full time work schedule for Kristy Pugh, the new research assistant (1 April 2014; Table 5).
- Welcomed a representative of the TRR software developers from Swinburne Australia to address refinements to the software to meet our needs and to conduct training on the App for surgical evaluators (7 April to 17 April 2014).
- Finalized the evaluation app and initialized conducting the co-located surgical skills evaluations solely on the tablets using the RASP App in real-time (21 April 2014). Developed a training module to train evaluator to use the app (Appendix 4).
- Attended the annual meeting of the American Association of Anatomists at FASEB and presented results from the ASSET historical dataset analysis (27 April 2014, Appendix 18)
- Utilizing the comprehensive database of video clips demonstrating surgical technique from Phase 1 Expert and Novice subjects (compiled and reported on last quarter) and the training manual, we trained a total of 8 additional surgeons as reviewers to evaluate surgical skill and technique (14 May 2014).
- Logistics: a modification of the budget was submitted to better assign funding. The modification was accepted (June 2014) (Appendix 3).
- Implemented Cloud download and analysis of tablet co-located data (2 July 2014). Compiled, error checked and calculated metrics for completed data to date (14 Feb 2015).
- Hired a dedicated scheduler to find, contact, recruit, and schedule Phase III surgeons (1 October 2014; Table 5)

- Completed the baseline evaluations of 40 of the 40 Phase 2 surgeons (receiving ASSET training) and 39 of the 40 surgeons post-training (3 September 2014). One surgeon decided not to continue participating.
- UM IRB annual continuing review submitted (14 November 2014) and accepted (17 November 2014)
- Completed evaluations of 8 of 10 for Expert surgeons with the same metrics used to assess the Phase II and III surgeons to create a systematic “expert range” of surgical skill for comparison with other study participants (12 December 2014) (see Figure 1 & 3) .
- Completed 9 of the 40 Phase III ASSET alumni evaluations (12 December 2014) (see Figure 1 & 3).
- Completed review of anonymized videos for the first 12 completed pre and post evaluations (11 September 2014). An abstract was accepted for presentation at the Association for Surgical Education Conference (19 December 2014, Appendix 15)
- Recruited a substitute surgeon for the Phase II drop-out; thus completing the enrollment of 40 of the 40 Phase II participants (12 January 2015).
- Completed base-line evaluation of 40 of the 40 proposed Phase II surgical residents (10 February 2015, Figure 2).

Reportable Outcomes

- Continuing to compile an extensive surgical video library over a range of skill levels from head camera and ceiling mounted cameras.
- Completed the development and implementation of a mobile skills evaluation platform including a metric tool in an Android-based software application.
- One manuscript has been accepted for publication in the *Journal of Trauma*
 - Detailing the development of the objective skills assessment and preliminary data on the effect of training on surgical skill and competency (Appendix 10).
- One manuscript is in review with the *Journal of Surgical Research* (Appendix 9).
 - Detailing the effect of the ASSET course on self-reported surgical confidence scores by level and years of experience.
- Eight abstracts have been submitted and accepted for presentation at various professional meetings (Appendix 19)
- Two additional abstracts have led to manuscripts in preparation
 - Mackenzie et al (2015) Assessment of surgical anatomy skills in upper and lower limb vascular control and before and after training. *To be presented at Association for Surgical Education* (Appendix 15)
 - Garofalo et al (2015) Surface anatomy in the performance of a lower extremity fasciotomy before and after training. *To be presented at Federation of American Societies for Experimental Biology* (Appendix 16)
- Three additional abstracts are in preparation for submission to present at MHSRS 2015.
- Submitted a pre-proposal to continue to assess the acquisition and retention of surgical skill by examining the efficacy of multiple skills and knowledge refreshing methods - BA150077 - Titled Refreshing Combat Surgical Skills We were invited to submit a full proposal (13 January 2015, Appendix 20) and are preparing a full proposal for submission mid-April 2015.

- We have completed, error checked, updated and used the Phase 2 dataset for multiple analyses.
- Dr. Mackenzie (PI) successfully defended his candidacy for his UK Doctoral degree based on this research effort. (Appendix 21)

Conclusion

This project is progressing extremely well and is close to being on target for all Statement of Work tasks. Institutional Review Board approvals have been obtained swiftly and are up to date. Comparisons of the Phase II (before and after training) resident skills to those of expert surgeons and previously trained surgeons are yielding results that are generally supportive of the study hypotheses. These results also indicate that the metric tool developed to assess skill is capable of discriminating skill levels. The mobile platform and cloud-based evaluation download greatly facilitates the utility of the metric. However, continued adjustments are necessary to improve efficiency. Preliminary Analyses of Phase I and Phase II video task analysis indicate that there is good inter-rater reliability for many of the evaluation criteria for distinguishing expert surgical technical performance and confirms the utility of remote skills evaluation. Phase 2 studies comparing surgical technical skills metrics before and after ASSET training are ongoing and 8/40 Phase 2 surgeons are enrolled for follow-up 12 to 18 months after their ASSET training. Phase 3 (previously ASSET trained) recruitment is ongoing. The logistics of travel, the recent winter weather and limitations of access to current contact information have slowed the process of recruitment for this group. However, preliminary analyses indicate that the skills degradation for this group follows expected and objectively measurable patterns. This population will yield fruitful lines of inquiry. Eight experts have been evaluated and these data will greatly enhance comparisons of skill and objective identification of competency and improvement.

Appendices

Appendix 1: Abstract for AMSUS 2014

Evaluation of individual surgeon technical skills during four emergency procedures.

Colin F Mackenzie, Evan Garofalo, Hegang Chen, Valerie Shalin, Kristy Pugh, Stacy Shackelford, Sharon Henry, Mark Bowyer, Mark Fitzgerald, Joost Funke Kupper, George Hagegeorge, Peter Hu, Kon Mouzakis.

Background: Maintaining trauma specific surgical skills is a challenge for military surgeons. Objective assessment of surgical readiness is needed. We hypothesized that expert surgeon technical skill metrics could provide a reliable technical skill assessment for less experienced surgeons.

Methods: After Institutional Review Board approvals, surgical technical skills assessment metrics were developed from discussion with 10 expert surgeons, video review performing three vascular exposure procedures and lower extremity fasciotomy on both cadavers and hyper-realistic physical models, and a consensus conference. These same metrics were tested in 10 residents using Android tablet software and a head camera to capture 16 specific steps and techniques and 5 performance global ratings during the four procedures. Performance was then assessed on random video-clips of both experts and novices by 5 trained evaluators and compared with regression modeling and inter-rater reliability (ICC) analysis.

Results: Among 10 residents, scores showed no evidence of floor or ceiling effects. Occurrence of 16 expert technical skills, agreed upon by experts, was found in 51-59% of residents during the 4 procedures. Global overall performance rating was 54%. Global technical performance was 69%. ICC ranged from 0.79-0.99 for agreement both between raters and among most skills ratings.

Discussion: Evaluation metrics discriminated novices from an expert standard with excellent inter-rater reliability. Validation in a larger population and before/after skills training is required. Further work with simulated physical models may provide a mobile skills evaluation platform without cadavers.

Support: US Army (USAMRMC) W81XWH-12-JPC1

Development of a Trauma Readiness Metric Score for Surgeons

***Evan Garofalo, Stacy Shackelford, Valerie Shalin,
Megan Holmes, Jason Pasley, Elliot Jessie, Babak
Sarani, Sharon Henry, Mark Bowyer, Colin
Mackenzie (Presenter)***

**University of Maryland STAR Research Center, USAF C-STARS, Baltimore,
Wright State University , George Washington University & USUHS**

Funding: W81XWH-13-2-0028



DISCLAIMER

- This research and development project was conducted by the University of Maryland, School of Medicine and is made possible by a cooperative agreement that was awarded and administered by the **U.S. Army Medical Research & Materiel Command (USAMRMC) and the Telemedicine & Advanced Technology Research Center (TATRC)**, at Fort Detrick, Md under Contract Number: W81XWH-13-2-0028
- **The views, opinions and/or findings contained in this presentation are those of the author(s) and do not necessarily reflect the views of the Department of Defense and should not be construed as an official DoD/Army position, policy or decision unless so designated by other documentation. No official endorsement should be made.**

PROBLEM:

TRAINING & SKILL RETENTION GAP

- Fewer graduating residents document experience with vascular trauma. [1,2]
- Major vascular repairs for trauma by graduating chief residents (ABS data) decreased on average from 5.0 in 2001-2002 to 2.1 in 2010-2011 over the course of a residency in general surgery [3]
- The average number of fasciotomies reported was 1.2; exposures of the brachial artery by chief residents in 2010-2011 was 0.0.
- Inexperience with LE fasciotomy has contributed to loss of life and limb due to incomplete or delayed fasciotomies.[4]
- Duration of Surgical Skills Retention and identification of need for re-training remain unknown
- Objective measures of acquisition & retention combat specific surgical skills are required

[1] J Trauma. 2003;54(1):161-3; [2] Mil Med. 1989; 154(11):581

[3] http://www.acgme.org/residentdatacollection/documantation/statistical_reports.asp; [4] J Trauma. 2008; 64 (2 suppl) S153-162

SOLUTION:

Performance metrics Before and After Training

FOUR ASSET Surgical Procedures

- Femoral artery injuries prevalent in Lower Extremity [LE] [1];
- Upper Extremity: Axillary artery (23%), Brachial artery (58%) [2].
- Extremity wounds in combat casualties develop compartment syndrome; fasciotomy, esp. of LE, is frequently required. [3]

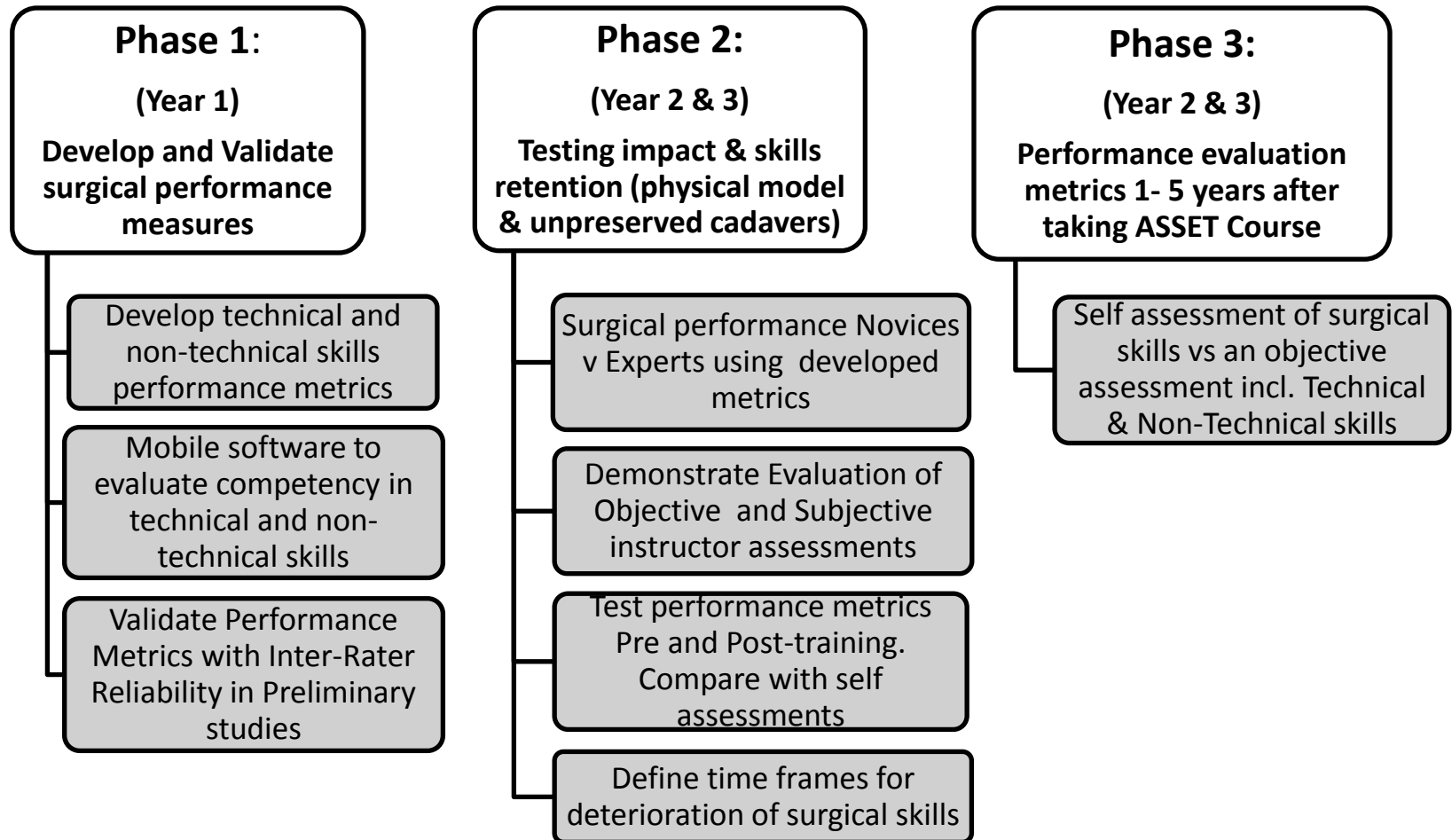
HYPOTHESIS:

Validated surgeon performance measures will demonstrate the effectiveness of ASSET training, document surgical competence, detect skill deterioration in combat-relevant surgical skills and provide critical insight into the duration and degradation of those skills over time periods of 1- 5 years.

Military Relevance

- **Bleeding is the leading cause of early preventable death in military & civilian casualties.**
- **Difficult for military trauma surgeons to maintain proficiency in exposure and vascular control of major blood vessels**
- Vascular injury in modern combat is five times that reported in previous wars [1].
- 50-70% of all injuries treated during Operation Iraqi Freedom are extremity ~~vascular~~ injuries [2].
- Exsanguination from upper and lower extremity wounds is the leading cause of preventable death on the modern battlefield [3].

RASP project Description & Phases



Outcome

Modified surgical skills program with demonstrable surgical skills performance and retention

METHODS – Phase 1

- **Video Record** 10 Experts “Talk Aloud” during 4 ASSET procedures.
- Video Record 10 Non-ASSET Trained novices
- **Consensus Conference** among experts: identify essential expertise, common errors and correct technical Skills = **Evaluation Metrics**.
- **Develop Standard Script: Train Evaluators:** Incorporate Script and Evaluation Metrics into **Mobile Tablet** for ‘real-time’ evaluations and data collection. **Validate:** Using blinded video review

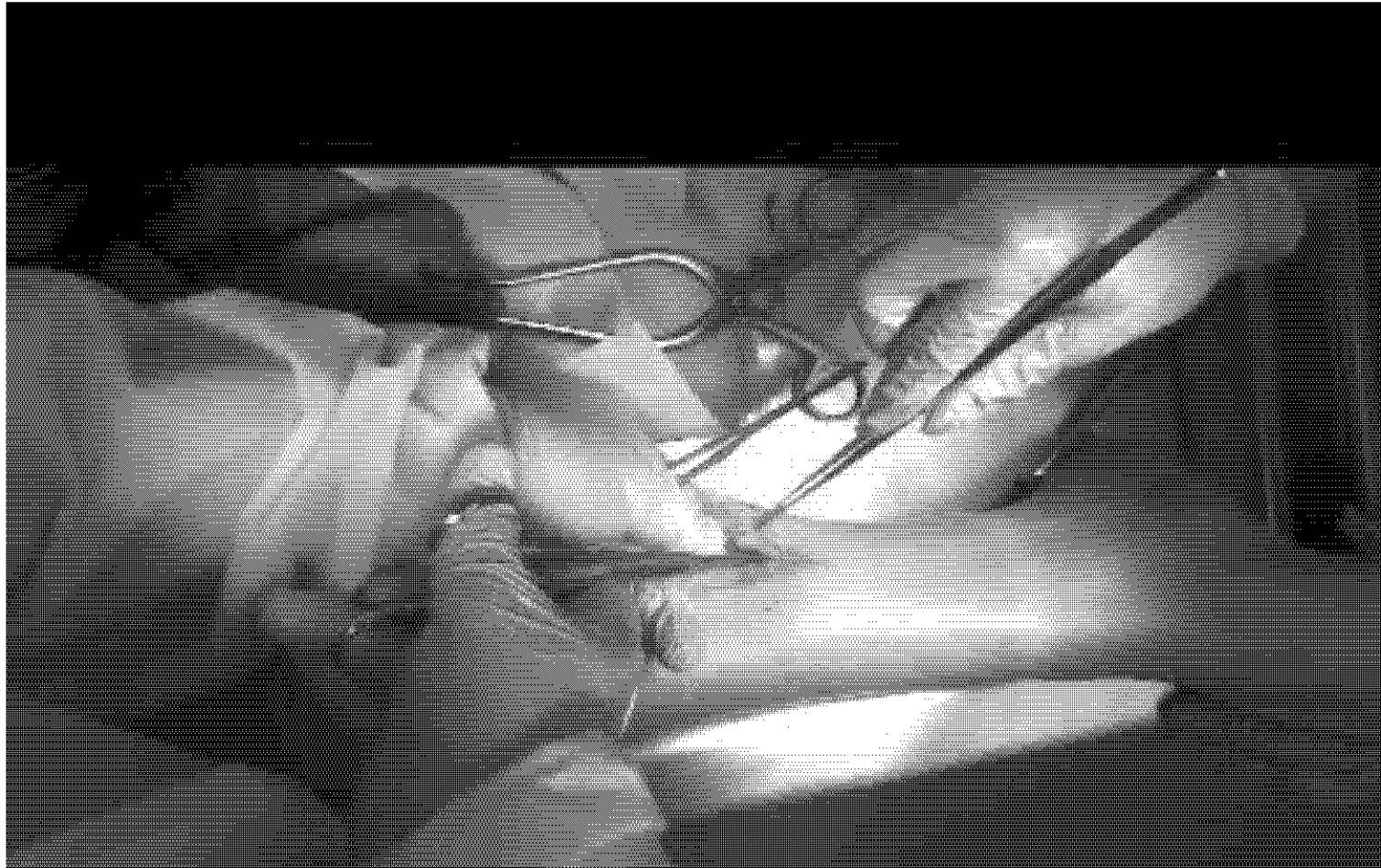
- 1) Using only small portion of incision space
- 2) “Keyhole” Surgery



- 1) Inappropriate incision
- 2) Lack of Femoral artery anatomy knowledge
- 3) Incorrect knife holding



Inadequate length Medial fasciotomy incision



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Trauma Readiness Index (TRI) Metric

- Video 10 experts (E) and 10 novice (N): 4 RASP procedure(AA, BA, FA, FAS) in fresh cadavers
- Index of Points Awarded / Points Possible for:
 - **Procedural skills:** 10 surgical steps, completion time
 - **Knowledge:** knowledge of anatomy, diagnostic indications, management
 - **Technique points:** operative maneuvers and tissue handling common to experts
- Evaluations by trained video reviewers (n=5) blinded to E or N clips compared by item analysis.
 - Evaluators also awarded 5 Global performance ratings & and overall performance “grade” (%)
- Descriptive regression modeling. Intra-class correlation coefficient (ICC) for Inter-Rater Reliability

Validation of Metrics: Inter- Rater (ICC) Reliability

Technical Skills (5 Raters)

	Intraclass Correlation Coefficient (ICC)			
Technical Skill	Axillary artery exposure	Brachial artery exposure	Femoral artery exposure	Lower Extremity Fasciotomy
Obtains necessary exposure	0.98	0.92	0.79	0.97
No unnecessary dissection	0.96	0.91	0.96	0.94
Proceeds at appropriate pace	0.97	0.88	0.94	0.97
Performs with logical sequence	0.93	0.87	0.97	0.95

Results of Preliminary TRI testing

- Among 10 Novice: No Floor/Ceiling effects of TRI
 - Novice technical skills =51-59% of the 16 observed for Experts
 - Global overall performance rating = 54%
 - Global Technical Performance = 69%
 - ICC ranged from 0.79 – 0.99 depending on procedure among AA, BA, FA, FAS
-
- **Conclusion:** *TRI Evaluation metrics discriminated N from E with excellent Inter Rater Reliability.*
 - *Validation in a larger population Before/After skill training is needed*

TRI Testing Before/After ASSET training

n = 12

- TRI for 3 vascular exposures and FAS improved 14% after training.
- Procedural steps skills increased 21%
- Surgical Technical Skills increased 12%
- Overall knowledge improved 4%
- Anatomic specific knowledge improved 17%
- Time to completion decreased 4.3 min (13.4 to 9.1)
- N= 40 surgeons now enrolled... analysis on-going

	Improvement	p-value
Time (minutes)	-4.3 minutes	0.000001
Procedural steps score	21%	0.000001
Knowledge Score	4%	0.013
Anatomic	17%	0.00001
Indications	3%	0.044
Technical skills score	12%	0.0001
TRI	14%	0.0001
Evaluator rating	6%	0.0004

Summary / Conclusions

- Lack of currency in trauma surgery skills has been identified as a significant barrier to military medical readiness for surgeons.
- No clear standards/ data currently exist on factors affecting critical combat-relevant surgical skills
- The RASP App and the physical model system that will emerge from these studies will be readily deployable as a means of evaluating surgeon readiness to perform emergency vascular control procedures
- (See Poster Abstract # MHSRS-673 - Mobile Platform to Evaluate Individual Surgeon Technical Skills. Poster Session #: 1 Poster Board #: 109 Tuesday 19th Aug)

Appendix 2: Presentation given at MHSRS 2014; Trauma Readiness Index

Development of a Trauma Readiness Metric Score for Surgeons

Evan Garofalo, Stacy Shackelford, Valerie Shalin, Megan Holmes, Jason Pasley, Elliot Jessie, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie

Background: Maintaining trauma-related surgical skills during peace-time practice is a challenge. Vascular exposure skill in trauma is an essential preparation for deployment. To create the necessary trauma-specific skills evaluation protocol, we hypothesized that comparison of expert and novice surgical knowledge and technical skills would identify discriminatory metrics for deployment readiness.

Methods: Through video task-analysis of 10 attending trauma surgeons and 10 general surgery residents performing three vascular exposures [axillary (AA), brachial (BA), femoral arteries (FA)] and lower extremity fasciotomy (FAS) in fresh cadavers, we identified knowledge and technical skills common among experienced surgeons. *Knowledge:* 8 questions, including knowledge of injuries, indications for surgery and complications, *Technical:* completion of 10 specific surgical steps and techniques, 6 operative maneuvers common to experts, and 5 performance global ratings were combined to create a trauma readiness score. These were assessed for 10 residents in a blinded video review by 5 trained evaluators with item analysis and descriptive regression modeling for development Trauma Readiness Index (TRI).

Results: Inter-rater reliability, determined by intraclass correlation coefficient ranged between 0.79-0.98. Average scores were: knowledge questions AA 62%, BA 81%, FA 93%, FAS 62% answered correctly; expert technical skills found in residents: AA 55%, BA 51%, FA 59%, FAS 53%. Global ratings (median Likert 1-5, average % correct): Technical Skills: 3, 54; Indications/Complications: 3, 81; Anatomy knowledge: 3, 78; Readiness 2.5; Global evaluation impression score (1-100) 69. The average TRI for all procedures was 62/100.

Conclusion: Trauma readiness metric discriminated expert from novice performance in both technical and non-technical skills with excellent interrater reliability. Validation in a larger population and with trauma skills training is required.

W81XWH-13-2-0028

June 27, 2014

Dear Ms. Bane,

I would like to request approval of some budget modifications to W81XWH-13-2-008

“Use of Performance Measures to Evaluate, Document Competence and Deterioration of Advanced Surgical Skills Exposure for Trauma (ASSET) Surgical Skills". The Title was abbreviated as Retention and Assessment of Surgical Performance (RASP)

PRINCIPAL INVESTIGATOR: Dr. Colin Mackenzie.

These budget modifications will not change the overall cost of the project, nor will they change the scope of work or the deliverables.

The justification for the requested budget changes is shown below and the source of funds is the carry-over of \$212K. That occurred from year 1:-

The carry-over of funds that occurred in Year 1 was due to factors shown in 1) below, including slow start-up due to:

1) an inability to hire qualified personnel candidates with expertise in Human Anatomy for the Research Associate/Assistant positions despite advertising in the Anatomy journals, newspaper and within the UM system, 2) Non-hiring of a Bio-informatics person as we originally had no data, but now plan to hire for this position (see 7 below). We were constrained by Sequestration for our Kick-Off meeting in April 2013. No personnel were able to travel from Ft Detrick, but we set up a Telecommunication line. In addition the mid –term meeting we had scheduled coincides with a Mid Term reporting invitation by Ft Detrick.so these fund expenditures were less than budgeted. Dr. Valerie Shalin, one of our Consultants was on Sabbatical Leave in France, so although she did participate in our weekly conferences by Telecommunications it was not for as many hours as budgeted. She is now back from Sabbatical and will ‘catch up’ these hours. Travel re-imbursement requests for Phase 1 and Phase 2 candidates were less than budgeted and Evaluator honorarium were not all paid out as approval has not been obtained (see item 3 and 9 below). Our video technician (George Hagegeorge) was budgeted at 50% effort, but only provided 30% effort during year 1 start up. Now that we are collecting and rendering hugely increased amounts of video data we would like approval to increase his effort to 70% as of July 1st 2014

We request modification of the budget to use the year 1 carry-over funds as follows:

- 1) **Increase in expenditure on Faculty Salary:** Faculty Salary costs have increased beyond budget because Dr. Hegang Chen (Statistician to the effort) has been promoted from Associate to Full Professor in the Department of Epidemiology (budgeted+15%: \$130,002) and Dr. Hu has been promoted from Assistant to Associate Professor in the

Department of Anesthesiology (budgeted+10%: \$142,119). Dr Garofalo was hired at 100% effort as the Research Coordinator of this project effort and was in addition appointed as an Assistant Professor in the Department of Anatomy at the University of Maryland School of Medicine. Salary for Dr Garofalo is \$71,595 versus the budget in the funding of \$65,500

- 2) **Cost of Living Allowance:** There was a 3 % COLA approved in 2014 (the first in 6 years) by the State of Maryland for all personnel in the project effort.
- 3) **Payment of Ad Hoc Script Readers:** We have been unable to hire adequately qualified Research Associate Staff with experience in Human Anatomy, despite advertising both internally and in Anatomy Journals and Local Newspapers. As a result we have underspent our budget for Research Associate Staff. We would like to use funds to hire some ad hoc PhD program staff from the Johns Hopkins Department of Anatomy providing a per diem incentive for script reading during the actual surgical procedures being carried out for this project.
- 4) **Head Mounted Video Cameras:** We had difficulty capturing video data when using the overhead fixed video cameras and the audio collection was not ideal with simultaneous study sessions within 6 feet of each other. We purchased head-mounted video camera; approximate additional cost \$6,500 for head mounted audio video cameras from our supplies budget. A preliminary assessment shows that these head cameras have corrected the problem. (This is covered under supplies..each camera is < \$150 per camera. A representative quote is attached).
- 5) **Video Technician (George Hagegeorge) increase effort to 70% from current 30%** as of July 2014 due to hugely increased collection of video data and the time consumed in rendering video clips suitable for expert reviews and for work with investigators to analyze the collected audio-video records . As an indication of this effort, each candidate in Phase 2 has 3 separate surgery sessions during which they are video recorded performing 4 different surgical procedures on a cadaver and the same 4 procedures on physical models i.e. 24 procedures X 3 = 72 surgeries , each surgery is of about 45 minutes duration X 40 Phase 2 candidates (as here are 40 candidates to be enrolled in Phase 2) .
- 6) **Increase in Travel Allocation:** We were constrained by Sequestration for our Kick-Off meeting in April 2013. No personnel were able to travel from Ft Detrick, but we set up a Telecommunication line. In addition the mid –term meeting we had scheduled coincides with a Mid Term reporting invitation by Ft Detrick. We request approval to move these funds into UM travel budget which is currently inadequate to cover anticipated Travel costs. The project has been very productive and we anticipate wanting to present at MHSRS, AMSUS and AAST (abstracts about the project effort have been submitted to all of these meetings) and other important Scientific meetings including for Abstracts accepted for presentations at the American College of Surgeons, and the American Society of Anesthesiologists meetings.

- 7) **A Research Coordinator/Scheduler** is needed to schedule the Phase 2 Surgeons with The Anatomy Board for the remainder of their pre and post training visits and their 12 or 18 month follow up visits as per SOW.

(Task 2c) Forty surgeons from 2a) perform 4 ASSET procedures in random sequence on physical model and cadaver, months 11-18. Task 2 d) Reevaluate 2c surgeons at either 12 (n=20) or 18 months (n=20) on physical model & cadaver.

In addition this Research Coordinator/Scheduler role would also schedule the Phase 3 participants to return in cohorts of 10 to be re-tested for skill retention 2,3, 4 and 5 years after ASSET training

As per Phase III SOW : Examine various aspects of skills degradation over time, including comparison of skills degradation among 40 surgeons participating in past ASSET courses (cadaver model training only) and those participating in the study-based ASSET training curriculum.

Task 3a) Recall and retest previously ASSET-trained surgeons on cadaver at intervals of 2-5 years from original training, months 11-30. DFA: months 32-36 DFA; AC: Repeat ASSET procedures in 40 previously trained surgeons. Complete skills assessments as originally administered and TRR Performance Audit; POC: 15%

- 8) **A Bio-informatics Graduate Research Assistant** needs to be hired for data input and running software macros as data accumulates.
- 9) **A Surgeon Research fellow** to be hired to be trained to assist with video analysis and help with conduct of the procedures in the Anatomy Board
- 10) **Evaluator incentives:** We would like approval for a \$75 per session evaluation honoraria for non-military evaluators and for military personnel working on non- duty leave-time. The amount allocated to this would be an additional \$34,020

$20 \text{ (Phase 1 sessions)} + 40 \text{ (Phase 2 participants)} * 3 \text{ (sessions)} + 40 \text{ (Phase 3 sessions)}$
 $= 180$

\$75/session

2 evaluators scheduled/session

$180 * 75 = \$13,500$

$\$13,500 * 2 \text{ evaluators per session} = \$27,000 + \text{IDC} = \$34,020$

The evaluations require expert surgeons whose time away from clinical practice for the time-consuming task and we have had some difficulty filling the 2 evaluators slots/subject.

- 11) **Advisory Board:** We have agreement in discussion with Dr Talbot for an Advisory Board of International experts and request approval to add \$12,234 necessary to cover per diem and travel for one visit this year. The Advisory Board Participation will include

capacity building and result in further research proposals with additional SOW. For each member of the Advisory Board we request per diem at government rates (including meals and accommodations) and Honoraria of \$500 per day spent in association with their role as an Advisory Board Member to this project. For all Advisory Board Members this will include days spent travelling. Air travel will be provided in Economy Class. One visit for each Advisory Board Member will be budgeted

Budget Total = \$12,234

Dr Nick Sevdalis: Funding for 2 days travel from and return to UK. 2 Days Advisory Board meetings (4 days at \$150/night and per diem \$50, and Honoraria \$500 + Round Trip Airfare UK to Baltimore (\$1576) and Transport to and from airports (\$200) = \$ 4,576

Professor Charles Vincent 2 days travel from and return to UK. 2 Days Advisory Board meetings (4 days at \$150/night and per diem \$50, and Honoraria \$500 + Round Trip Airfare UK to Baltimore (\$1576) and Transport to and from airports (\$200) = \$ 4,576

Professor James Shanteau 2 days travel from and return to Kansas. 2 Days Advisory Board meetings (4 days at \$150/night and per diem \$50, and Honoraria \$500 + Round Trip Airfare Kansas to Baltimore (\$282) and Transport to and from airports (\$200) = \$3,082.

12) Additional cadavers and costs associated with conducting 10 expert video recording of all 4 procedures:

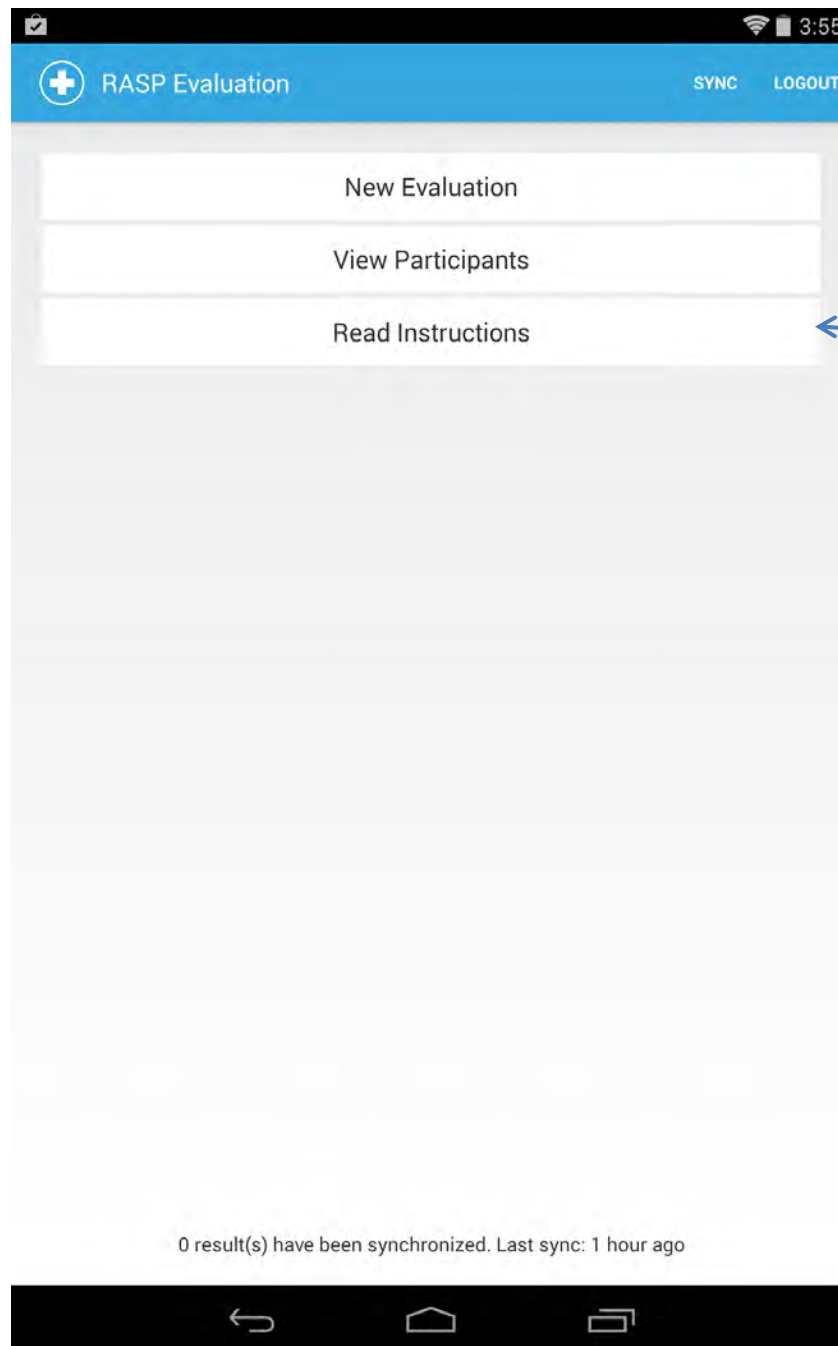
We have used more cadavers than the exact number we requested (2 candidates per cadaver x 100) anticipated because of last minute “no-shows” resulting in a ½ cadaver being un-used and another cadaver being required for the re-scheduling of this candidate. In addition to requesting approval of the cost of 20 additional cadavers and Anatomy Board time we are required to evaluate 10 experts using the metrics developed in Phase 1 of the project, so that we have a comparison to the Novice surgeons in Phase 2 using the same criteria, and the Phase 3 surgeons returning 2- 5 years after ASSET Training to determine their skill degradation in comparison to the Experts. The same incentive (\$1,000) will be paid to these 10 Experts as was paid to the Phase 1 Experts for participation and taking time out of their Attending Surgeon Clinical roles

The Requested Modified Budget and Original Budget are attached.

Please let me know if you need more information,

Thanks,

Colin Mackenzie



Script Reader:
Read RASP evaluation
instructions to
participant first



3:56



Instructions

Show slides and read the following text

You are here today to participate in a study during which we will evaluate your current knowledge and skills regarding the management of patients with certain traumatic injuries.

We will present you a total of four cases studies that will focus on dealing with specific traumatic injuries.

For each case, I will ask you to first describe:

1. The structures that you suspect might be injured
2. The physical findings you would specifically look for
3. The need for any additional studies and treatments
4. The need for surgical intervention

We will then transition to the patient being in the operating room and I will ask you to:

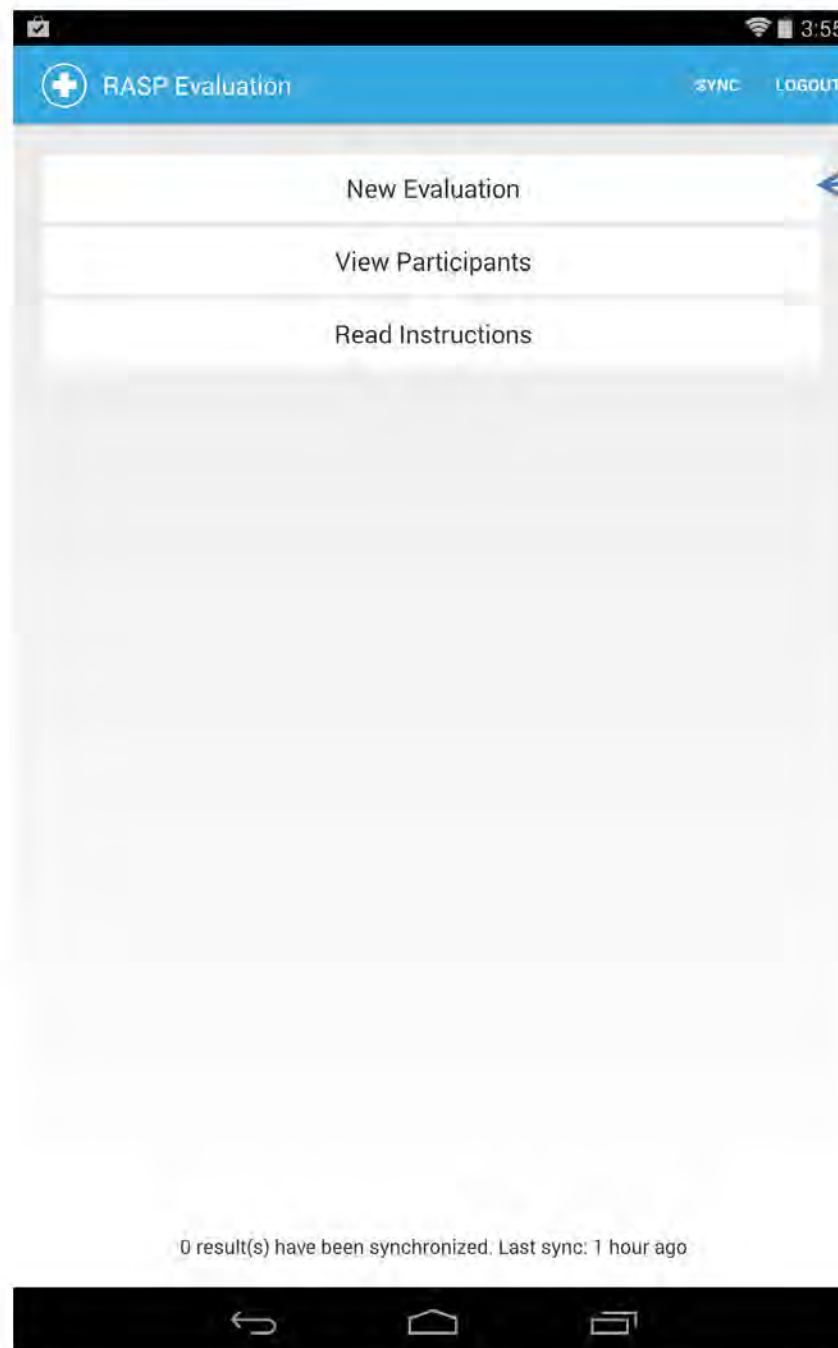
1. Describe how you would position and prep the patient for surgery
2. Mark the key landmarks for your incision
3. Perform the indicated procedure using the available instruments
4. As you perform each procedure you will be asked to speak out loud, describing the steps as you perform them
5. It is not necessary to rush through the procedure
6. Once you start the procedure, I will try not to interrupt you
7. Perform the procedure as you would with a real patient to allow accurate assessment of your surgical technique
8. You will have 20 minutes to complete each indicated procedure. Time will begin at your first incision

Do you have any questions?

If you need any assistance with instruments or retractors please let us know.

Close





All e-team:
Select New Evaluation

6:02

+ New Evaluation

Select Visit

Pre training

Participant Name

21: Brenessa Lindaman

Select Procedure

Axillary Artery, Foxtrot

Select Type

Cadaver

Begin Evaluation

Can also get to evaluation instructions here!

Pre-ASSET training
Post-ASSET training
Retention

Select participant



3:56



View Participants

Select Participant

21: Brenessa Lindaman

21: Brenessa Lindaman

22: Isaac Howley

23: Noelle Saillant

24: Sean Davitt

25: Graham Laurence

26: Franz Yanagawa

27: Seth Goldstein

28: Vicente Valero

29: Susan Kartiko

30: Zoe Maher

31: Phil Batista

32: Melissa Miles

33: Babak Orandi

34: Andrew Dhanaspoon



6:02

+ New Evaluation

Select Visit

Pre training

Participant Name

21: Brenessa Lindaman

Select Procedure

Axillary Artery, Foxtrot

Select Type

Cadaver

Begin Evaluation

Select:
Procedure Script, Trial

Cadaver
Model

3:57

+ New Evaluation

Select Visit

Pre training

Participant Name

21: Brenessa Lindaman

Select Procedure

Axillary Artery, Foxtrot

Axillary Artery, Foxtrot

Brachial Artery, Foxtrot

Femoral Artery, Foxtrot

Fasciotomy, Foxtrot

Axillary Artery, Lima

Brachial Artery, Lima

Femoral Artery, Lima

Fasciotomy, Lima

Axillary Artery Abridged, Oscar

Brachial Artery Abridged, Oscar

Select:
Procedure Script, Trial

You will have printed
instructions for which of
these scripts and in what
order you should select
for each participant

3:57

+

Pre-Treatment

?

Question 1

What are the structures you suspect could be injured along the path of the bullet?

The participant described each of the following as potentially injured

	Yes	No
Axillary Artery	☒	☐
Axillary Vein	☐	☐
Brachial Plexus	☒	☐
Lung	☒	☐
Subclavian Artery	☒	☐
Subclavian Vein	☐	☐
Mediastinal structures	☐	☐
Bones	☒	☐

Comments

Back

Next

Touch here for
Case Description



Type your initials into the first
comments box, please!

3:57

+

Pre-Treatment

?

Question 1

What are the structures you suspect could be injured along the path of the bullet?

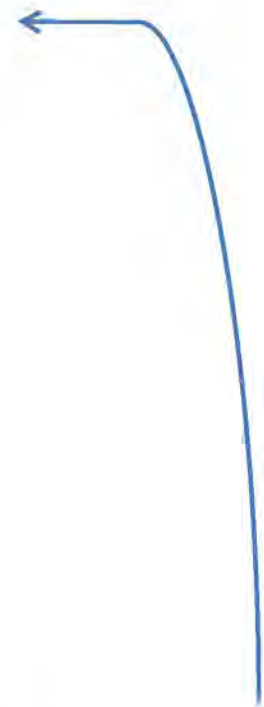
The participant described each of the following as potentially injured

	Yes	No
Axillary Artery	☒	☐
Axillary Vein	☐	☐
Brachial Plexus	☒	☐
Lung	☒	☐
Subclavian Artery	☒	☐
Subclavian Vein	☐	☐
Mediastinal structures	☐	☐
Bones	☒	☐

Comments

Back

Next



Must fill all options before clicking NEXT

3:58

+

Pre-Treatment

?

Question 1

What are the structures you suspect could be injured along the path of the bullet?

The participant described each of the following as potentially injured

	Yes	No
Axillary Artery	☒	☐
Axillary Vein	☐	☒
Brachial Plexus	☒	☐
Lung	☒	☐
Subclavian Artery	☒	☐
Subclavian Vein	☐	☒
Mediastinal structures	☐	☒
Bones	☒	☐

Comments

Back

Next



← Now touch NEXT

3:59

+

Pre-Treatment

?

The patient's blood pressure is 85/65 and HR 110 and is unable to move his arm, has decreased sensation and absent brachial, radial, and ulnar pulses.

What additional studies would you perform to help you identify or rule out specific injuries in this patient?

The participant described each of the following as additional studies

	Yes	No
FAST exam to look for pericardial tamponade, hemothorax, pneumothorax		
Chest X-ray		
A marker (eg. paperclip) is placed to mark wound prior to x-ray		
CT of Chest		
CT of Angiogram		
Angiogram		

Errors

Fails to obtain CXR

Innapropriate use of CT and Angio*

*All of the above tests are acceptable possible studies but the participant should clearly indicate these tests should only be done in a hemodynamically stable patient. Without this qualifier, performing any of these tests prior to taking this patient to the OR has potential for negative outcome and should result in negative value scoring.

Back

Next

Error Options:
Can only select
an error if the
related answer
is selected



4:00

+

Operating Room

?

The prep should include

	Yes	No
The entire chest	☐	☒
States possible need for sternotomy for proximal control	☒	☐
The entire arm and hand on the affected side	☐	☒
States need to evaluate perfusion to the hand	☒	☐
The thigh/groin for possible vein harvest	☐	☒
The neck	☒	☐
States possible need to expose subclavian artery for proximal control	☒	☐

Errors

Fails to prep entire chest	☒
Fails to prep entire upper extremity	☒
Fails to prep the thigh for vein harvest	☒

Comments

Back

Next

Error Options:
Can only select
an error if the
related answer
is selected



4:01

+

Procedure

?

Now I would like you to get control of the Axillary Artery proximal to the wound by dissecting and placing a vessel loop around the artery. As you operate, speak out loud and identify each step of the procedure - you should operate at a comfortable pace. The procedure will be deemed complete once you have placed a vessel loop around the axillary artery to obtain proximal control. Do you have any question? If not, please proceed.

Exposure of Axillary Artery

The participant describes and performs each of the following steps

Timer 00 min 00 sec

PauseReset

	Yes	No	Timed
Knife to skin			Start timer
Initial skin incision is adequate to perform exposure			00:00
Splitting or dividing Pectoralis Major			00:00
Divides Pectoralis Minor			00:00
Correctly identifies Axillary Artery			00:00
Correctly identifies Axillary Vein			00:00
Correctly identifies brachial plexus			00:00
Controls the Axillary Artery proximal to injury			00:00
Stop procedure			Stop timer

Back

Next

Shows duration

Can Pause timer if necessary

Touch to start at Knife to Skin

Remember to stop timer after 20 min or when procedure is complete

4:02

+

Procedure

?

Exposure of Axillary Artery

The participant describes and performs each of the following steps

Timer 00 min 58 sec

Resume

Reset

	Yes	No	Timed
Knife to skin	☒	☐	00:00
Initial skin incision is adequate to perform exposure	☒	☐	00:03
Splitting or dividing Pectoralis Major	☒	☐	00:03
Divides Pectoralis Minor	☒	☐	00:30
Correctly identifies Axillary Artery	☐	☒	00:30
Correctly identifies Axillary Vein	☒	☐	00:13
Correctly identifies brachial plexus	☐	☒	00:14
Controls the Axillary Artery proximal to injury	☒	☐	00:19
Stop procedure	Stop timer		

Errors

Incorrectly identifies the Axillary Artery and does not recognize or correct error	☐
Incorrectly identifies the Axillary Artery but is able to recognize and correct	☒

Back

Next

Error Options:
Can only select
an error if the
related answer
is selected

4:03

+ Procedure
 ?

Correctly identifies Axillary Vein		00:13
Correctly identifies brachial plexus		00:14
Controls the Axillary Artery proximal to injury		00:19
Stop procedure	Stop timer	

Errors

Incorrectly identifies the Axillary Artery and does not recognize or correct error	
Incorrectly identifies the Axillary Artery but is able to recognize and correct	

Technique Points (UTA: Unable to Access)

Exposes arteries by dissecting directly on anterior surface

Poor	Fair	Good	Very Good	Excellent	UTA
------	------	------	-----------	----------------------	-----

Manipulates artery by grasping adventitia

Poor	Fair	Good	Very Good	Excellent	UTA
------	------	------	-----------	----------------------	-----

Uses instruments properly

Poor	Fair	Good	Very Good	Excellent	UTA
------	------	------	----------------------	-----------	-----

Positions body to use instruments to best advantage

Poor	Fair	Good	Very Good	Excellent	UTA
------	------	-----------------	-----------	-----------	-----

Proceeds at appropriate pace with economy of movement

Poor	Fair	Good	Very Good	Excellent	UTA
------	------	------	----------------------	-----------	-----

Back

Next

Only page where you can advance before all fields are completed.

Use to complete Discriminatory Criteria

4:03

+

Procedure

?

Question 9

Expert Discriminator Operative Field Maneuvers for Axillary Artery Exposure

	Yes	No
Operates through 'key-hole' or too small a skin incision		
Operates using full incision		
Excessive dissection		
Pointless digging and shifting around in surgical field		
Has a logical operating sequence		
Lacks anatomical knowledge		

Expert Discriminatory Instrument Use for Axillary Artery Exposure

	Yes	No
Improper instrument use (e.g. back-handed use)		
Incorrect instrument holding (e.g. forceps too near tips, thumb through scissors handle)		
Scalpel use: multiple tentative cuts or cuts tangentially		
Switches instruments excessively		
Effective use of blunt dissection		

Back

Next

Navigate between this page and Procedure

Evaluate Overall Knowledge
& Technical skill here

The screen is titled "Post-Procedure" with a plus icon on the left and a question mark icon on the right. Below the title is a section for "Overall Rating". It displays a score of 62% and a vertical scale from 50 to 100. The scale has a blue bar and a blue circle indicating the current score. To the right of the score is a legend for the rating scale:

- >90 **Excellent** I hope this individual is on call if I am injured
- 80-89 This participant will be able to perform the exposure with minimal difficulty in an expeditious fashion
- 70-79 The participant might need to look at a text to refresh their memory but will be able to perform the exposure
- 60-69 This participant could do the exposure with experienced help, but will struggle if left alone
- <60 The patient has exsanguinated. Participant is not ready to perform the exposure

Below the rating scale are two selection questions:

- Body Habitus of Cadaver**
Obese
- Cadaver Anatomy**
Normal

At the bottom are two buttons: "Back" and "Next".

If performed on a cadaver,
Select:

Cadaver Body Habitus

Obese
Average
Thin

Cadaver Anatomy

Normal
Variant

Global ratings for:
Knowledge, Technical skill &
Readiness here

4:04

Post-Procedure

Global Rating

Overall understanding of the evaluation and treatment of a patient with a suspected Axillary Artery injury

Poor	Fair	Good	Very good	Excellent
------	------	------	-----------	-----------

Core knowledge is very good with thorough understanding of the nuances of evaluation and diagnosis

Overall understanding of the surgical anatomy of the Axillary region

Poor	Fair	Good	Very good	Excellent
------	------	------	-----------	-----------

Good understanding of the regional anatomy. Can name most of the major structures and their relationships

Technical skills for exposing Axillary Artery

Poor	Fair	Good	Very good	Excellent
------	------	------	-----------	-----------

The participant demonstrated good technical skills with occasional wasted movements and errors in tissue handling

This participant is ready to perform exposure and control of the Axillary Artery

Poor	Fair	Good	Very good	Excellent
------	------	------	-----------	-----------

The participant might need to look at a text to refresh their memory but will be able to perform the exposure

Back

Next

The image shows a mobile application interface for a 'Post-Procedure' screen. At the top, there is a blue header bar with a white plus icon in a circle on the left, the text 'Post-Procedure' in the center, a white question mark icon in a circle on the right, and the word 'PRINT' further right. Below the header is a grey bar with the text 'Read the following text'. The main content area is white and contains several paragraphs of text providing evaluation results. At the bottom of the screen, there are two blue buttons labeled 'Back' and 'Next'. Below these buttons is a black bar with three white icons: a back arrow, a home icon, and a recent apps icon.

Post-Procedure **PRINT**

Read the following text

Your evaluation score is: **115.0 / 150.0 x 100 = 76.7%**

You've accumulated an error score of: **-6.0 points**

Your adjusted score is: **109.0 / 150.0 x 100 = 72.7%**

You have received a score of **62%** by the evaluator, which means "60-69 This participant could do the exposure with experienced help, but will struggle if left alone"

You have received a **4/5** for Overall understanding of the evaluation and treatment of a patient with a suspected Axillary Artery injury
"Core knowledge is very good with thorough understanding of the nuances of evaluation and diagnosis"

You have received a **3/5** for Overall understanding of the surgical anatomy of the Axillary region
"Good understanding of the regional anatomy. Can name most of the major structures and their relationships"

You have received a **3/5** for Technical skills for exposing Axillary Artery
"The participant demonstrated good technical skills with occasional wasted movements and errors in tissue handling"

You have received a **3/5** for This participant is ready to perform exposure and control of the Axillary Artery
"The participant might need to look at a text to refresh their memory but will be able to perform the exposure"

Back **Next**

Score report will be available after each procedure is complete.

Please wait to de-brief until all four procedures are complete.

Instructions for viewing results to follow.

4:05

+

Post-Procedure

?

PRINT

Read the following text

Your evaluation score is: **115.0 / 150.0 x 100 = 76.7%**

You've accumulated an error score of: **-6.0 points**

Your adjusted score is: **109.0 / 150.0 x 100 = 72.7%**

You have received a score of **62%** by the evaluator, which means "60-69 This participant could do the exposure with experienced help, but will struggle if left alone"

You have received a **4/5** for Overall understanding of the evaluation and treatment of a patient with a suspected Axillary Artery injury
"Core knowledge is very good with thorough understanding of the nuances of

You have received a **3/5** for This participant is ready to perform exposure and control of the Axillary Artery
"The participant might need to look at a text to refresh their memory but will be able to perform the exposure"

Evaluation Completed

Please advice the participant that the evaluation is complete.
Do you wish save and exit?

No

Yes

Back

Next

Finish and Save!



PostProcedure

Question 1

What are the structures you suspect could be injured along the path of the bullet?

The participant described each of the following as potentially injured

	Yes	No
Axillary Artery	☒	☐
Axillary Vein	☐	☒
Mediastinal structures	☐	☒
Bones	☒	☐

Comments

Back Next

Exit Evaluation

You are about to leave an uncompleted evaluation.
Any questions answered will be deleted.
Do you wish to continue?

Cancel Exit

Hit BACK too many times, this happens.

If you touch EXIT, evaluation will be lost.

Don't do that.

4:09

+

Pre-Treatment

?

Question 4

What are the physical findings and symptoms that indicate a diagnosis of compartment syndrome in the lower leg?

The participant describes each of the following

	Yes	No
Relates concept that one should have a low index of suspicion for making Dx		
The 5 P's: Pain		
The 5 P's: Paresthesias		
The 5 P's: Pallor/Pokilothermia		
The 5 P's: Pulselessness		
The 5 P's: Paralysis		
Limb may feel tense or hard		
States that waiting for the 5 P's to occur is waiting too long		

Comments

Back

Next

Script alteration:
need to select each P
separately – software
structure limitation

4:10

+

Operating Room

?

Question 10

Lateral Incision

Medial Incision

The participant has marked the lateral leg incisions in the following manner

	Yes	No
The lateral Incision is marked one-two fingers in front of the fibula (1.5-3.0 cm)		
Upper end of incision 2-3 fingers (3.0-6.0 cm) from tibial plateau (TP)		
Lower end of incision 2-3 fingers (3.0-6.0 cm) from Lat. malleolus		

Comments

Back

Next

Navigate between Medial and Lateral Tabs

Can advance without filling all fields in both tabs.

But have participant mark both sides before proceeding to the procedure

Question 11

Now I would like you to perform the lower extremity fasciotomy. As you operate, speak out loud and identify each step of the procedure. It is not necessary to rush through the procedure - you should operate at a comfortable pace. The procedure will be deemed complete once you have decompressed all four compartments. Do you have any questions? If not, please proceed.

Lateral Incision Medial Incision

LATERAL INCISION: The participant describes and performs each of the following steps

Timer 00 min 00 sec	Pause		Reset
	Yes	No	Timed
Knife to skin	Start timer		
Identifies Intermuscular septum / correctly identifies anterior and lateral compartments			00:00
Mentions perforating vessels as a way to find IM septum			00:00
Uses H-Shaped incision to open fascia			00:00
Under-runs fascia with closed scissor tips			00:00
Opens fascia with partially closed scissor tips			00:00
Points tips of scissors away from septum			00:00

Back Next

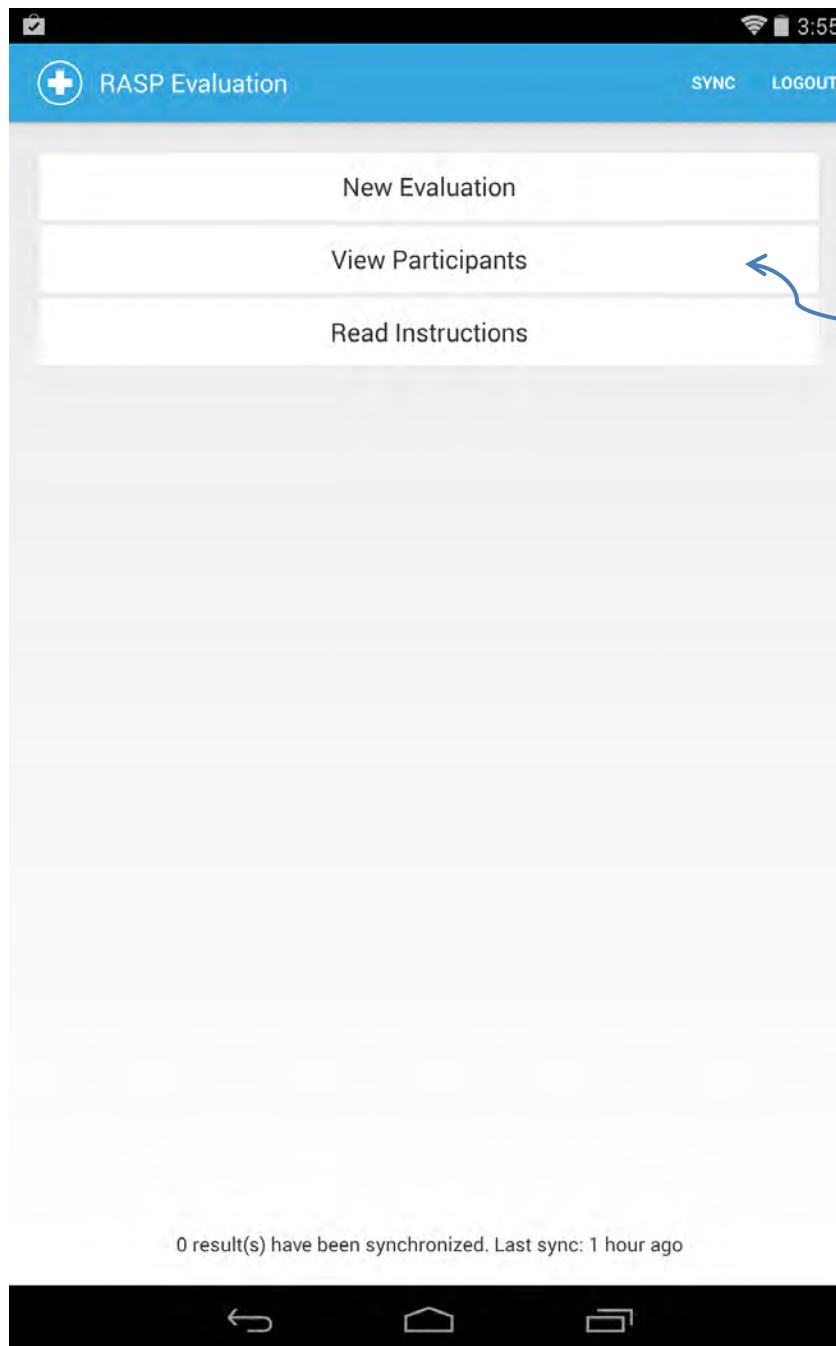
Navigate between
Medial and Lateral Tabs

Can advance without filling all
fields in both tabs.

But have participant
“complete” one side before
proceeding to the next

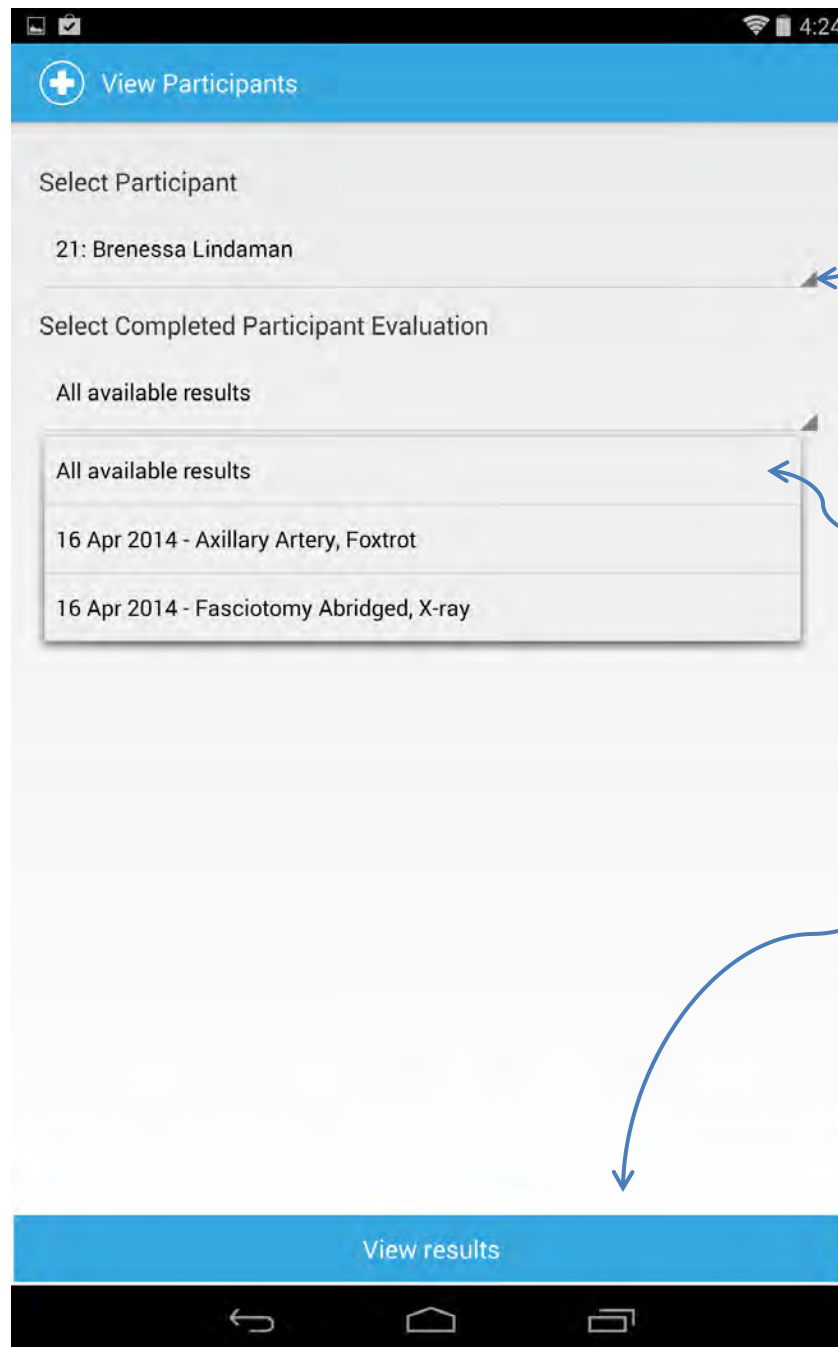
Must start and stop timer for
each Incision Tab!

Navigate freely to
Technique Points
Same Technique Points
for both tabs.



**To see all evaluation reports
for your participant for
de-briefing**





Select participant

Select All Available
Results

Or a specific procedure

Then touch here

Voilà:
Results for all saved
evaluations will appear

The screenshot shows a mobile application interface for 'Brenessa Lindaman Results'. The top status bar shows a Wi-Fi icon, a battery icon, and the time 4:24. The app header is blue with a white plus icon and the text 'Brenessa Lindaman Results', and a 'PRINT' button on the right. The main content area has a light gray background and displays two evaluation reports. The first report is for '16 Apr 2014 - Axillary Artery, Foxtrot' with details on case model type, body habitus, cadaver anatomy, evaluation score (78.0%), error score (-4.0 points), and adjusted score (75.3%). It includes a section for 'Evaluator Ratings' with five paragraphs of feedback. The second report is for '16 Apr 2014 - Fasciotomy Abridged, X-ray' with similar details and an error score of -2.0 points. The bottom of the screen shows a black navigation bar with three white icons: a back arrow, a home icon, and a recent apps icon.

Brenessa Lindaman Results PRINT

16 Apr 2014 - Axillary Artery, Foxtrot
Case model type: **cadaver**
Body habitus of cadaver: **obese**
Cadaver anatomy: **normal**
Your evaluation score is: **117.0 / 150.0 x 100 = 78.0%**
You've accumulated an error score of: **-4.0 points**
Your adjusted score is: **113.0 / 150.0 x 100 = 75.3%**

Evaluator Ratings

You have received a score of **65%** which means *"60-69 This participant could do the exposure with experienced help, but will struggle if left alone"*

You have received a **3/5** for Overall understanding of the evaluation and treatment of a patient with a suspected Axillary Artery injury
"Core knowledge is good with moderate understanding of nuances of evaluation and diagnosis"

You have received a **3/5** for Overall understanding of the surgical anatomy of the Axillary region
"Good understanding of the regional anatomy. Can name most of the major structures and their relationships"

You have received a **3/5** for Technical skills for exposing Axillary Artery
"The participant demonstrated good technical skills with occasional wasted movements and errors in tissue handling"

You have received a **3/5** for This participant is ready to perform exposure and control of the Axillary Artery
"The participant might need to look at a text to refresh their memory but will be able to perform the exposure"

16 Apr 2014 - Fasciotomy Abridged, X-ray
Case model type: **cadaver**
Body habitus of cadaver: **obese**
Cadaver anatomy: **normal**
Your evaluation score is: **59.0 / 104.0 x 100 = 56.7%**
You've accumulated an error score of: **-2.0 points**

Is the participant
finished for the day??

Print all reports to hand
to the participant at the
completion of the visit

MOBILE PLATFORM TO EVALUATE INDIVIDUAL SURGEON TECHNICAL SKILLS

Colin F Mackenzie¹, Mark Fitzgerald², Kon Mouzakis², Joost Funke Kupper², George Hagegeorge¹, Peter Hu¹, Evan Garofalo¹, M
Bowyer³, Sharon Henry¹, Stacy Shackelford⁴.

¹Shock Trauma Anesthesiology Research, University of Maryland Baltimore; ²The Alfred Hospital and Swinburne University, Melbourne, Australia; ³USUHS Bethesda, USA; ⁴USAF C-STARS Baltimore



Background: We developed surgical technical skills assessment metrics based on discussion with expert surgeons, video review of them performing four surgical procedures and a consensus conference. We describe the utility of a mobile app and video/audio capture system to gather data on surgical technical skills useful for training, telemedicine applications, evaluation in real surgery, cadavers and simulated surgical models.

Methods: Software was developed for Android tablets to capture assessments, which were uploaded to the cloud for analysis by trained evaluators (Fig 1). The system was tested during axillary, brachial, femoral artery exposure, and lower extremity fasciotomy surgery. For video/audio capture we compared three camera systems: a) Pan-tilt-zoom [PTZ] ceiling mounted, b) on mobile stand, c) head-mounted camera with laser pointer (Figs 2-4) and three audio capture systems: a) head worn boom microphone (Fig 5), b) ceiling mounted and, c) audio capture with head camera).

Results: The tablet facilitates capture of surgeon evaluation metrics less intrusively and without paper copies. Data from multiple evaluations stored in the cloud avoids data transcription. The \$120 head- mounted laser-directed camera captured up to 1.5 hours of surgical video and audio adequately to assess performance metrics remotely. The PTZ camera with boom/overhead audio system (\$90K) gave the best image, but was obstructed by the surgeon's head. The mobile stand mounted camera required constant movement to capture images of the surgical field.

Discussion: An inexpensive mobile data and video/audio capture system could be used to non-intrusively collect data to evaluate surgeon technical performance, with remotely situated evaluators. Further work will test simulated physical models (Fig 6) of the four surgical procedures with enough fidelity to realistically challenge surgical technique, to provide a mobile surgical skills evaluation platform ready for pre-deployment testing without the constraints of cadaver.

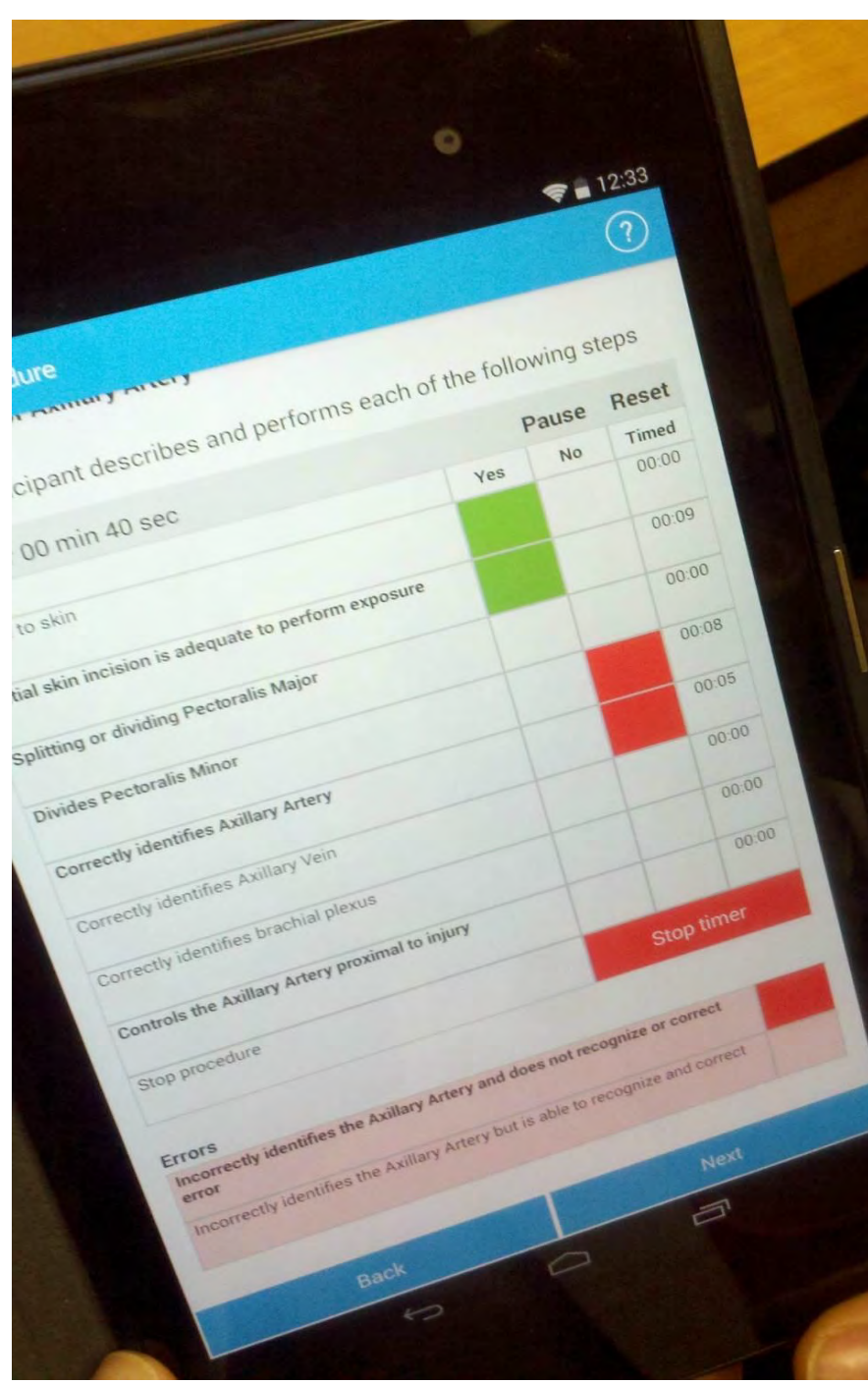


Figure 1
Tablet Showing RASP App, with Script, Case History, and Evaluation metrics

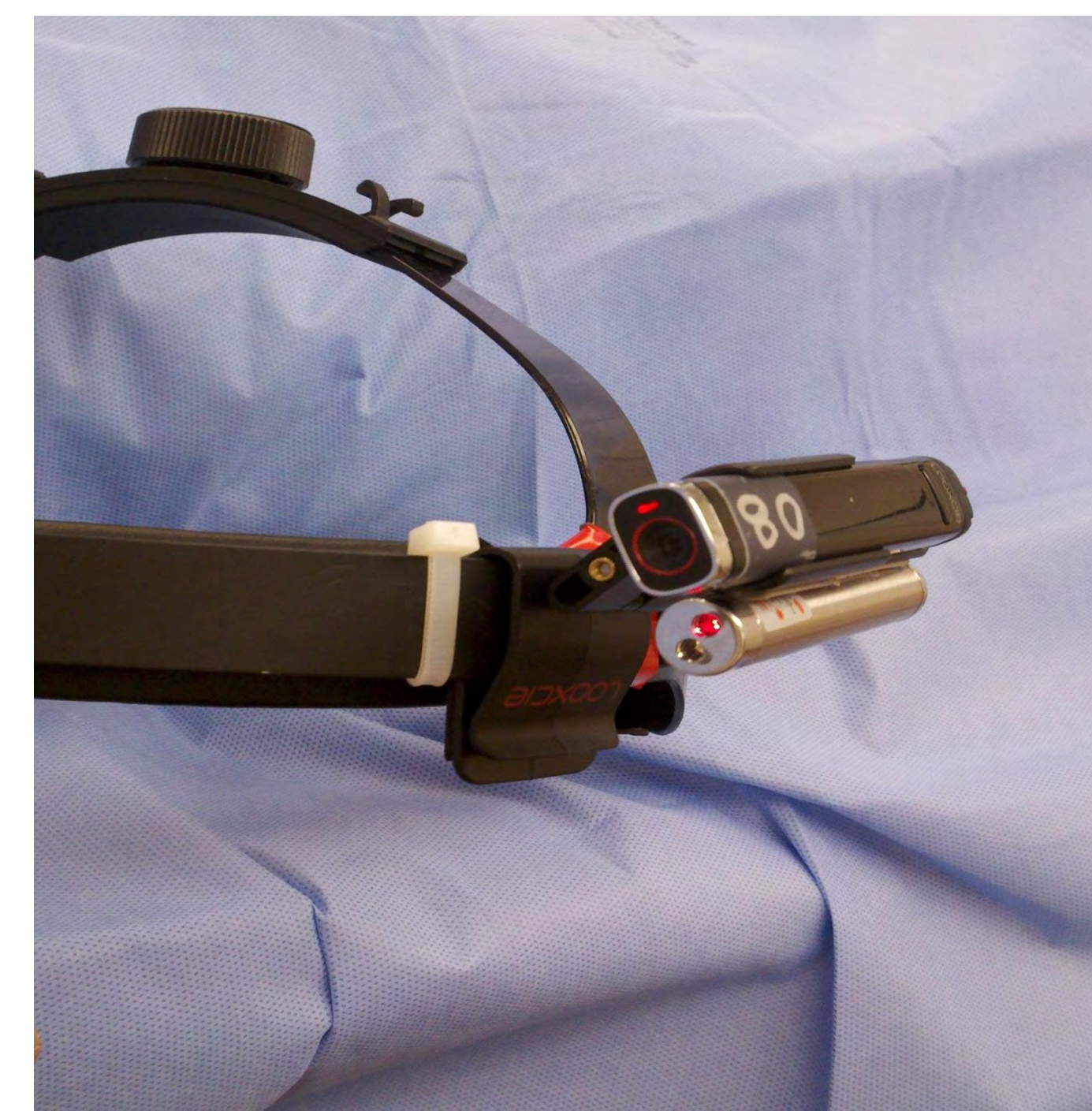


Figure 2
Detail of Head Cam and Laser



Figure 3
RASP evaluation showing participant wearing head camera



Figure 4
Focusing the Head Cam laser pointer



Figure 5
Head Cam and boom microphone



Figure 6
Hyper-Realistic Physical Model for Fasciotomy

Upper Extremity Model Realism Feedback

Please score the realism of Upper Extremity Model features below on a scale of 1 to 5

	1= No reality		5 = Very realistic		
	1	2	3	4	5
Skin	1	2	3	4	5
Subcutaneous tissue	1	2	3	4	5
Muscle	1	2	3	4	5
Fascia	1	2	3	4	5
Vasculature	1	2	3	4	5
Usefulness for Training	1	2	3	4	5
Realism for training	1	2	3	4	5
Anatomic reality	1	2	3	4	5

For the Upper Extremity model, please provide feedback on the following:

What are the strengths of the model?

What are the weaknesses?

Did you find anything about the model distracting?

Do you have suggestions for improvement?

Any other comments?

Thank you for your participation!

Lower Extremity Model Realism Feedback

Please score the realism of Lower Extremity Model features below on a scale of 1 to 5

	1= No reality		5 = Very realistic		
	1	2	3	4	5
Skin	1	2	3	4	5
Subcutaneous tissue	1	2	3	4	5
Muscle	1	2	3	4	5
Fascia	1	2	3	4	5
Vasculature	1	2	3	4	5
Usefulness for Training	1	2	3	4	5
Realism for training	1	2	3	4	5
Anatomic reality	1	2	3	4	5

For the Lower Extremity model, please provide feedback on the following:

What are the strengths of the model?

What are the weaknesses?

Did you find anything about the model distracting?

Do you have suggestions for improvement?

Any other comments?

Thank you for your participation!

Cadaver Upper Extremity Realism Feedback

Compared to a live patient, please score the cadaver upper extremity on a scale of 1 to 5

	1= No reality		5 = Very realistic		
	1	2	3	4	5
Skin	1	2	3	4	5
Subcutaneous tissue	1	2	3	4	5
Muscle	1	2	3	4	5
Fascia	1	2	3	4	5
Vasculature	1	2	3	4	5
Usefulness for Training	1	2	3	4	5
Realism for training	1	2	3	4	5
Anatomic reality	1	2	3	4	5

For the cadaver upper extremity, please provide feedback on the following:

What are the strengths of the model?

What are the weaknesses?

Did you find anything about the model distracting?

Do you have suggestions for improvement?

Any other comments?

Thank you for your participation!

Cadaver Lower Extremity Realism Feedback

Compared to a live patient, please score the cadaver lower extremity on a scale of 1 to 5

	1= No reality		5 = Very realistic		
	1	2	3	4	5
Skin	1	2	3	4	5
Subcutaneous tissue	1	2	3	4	5
Muscle	1	2	3	4	5
Fascia	1	2	3	4	5
Vasculature	1	2	3	4	5
Usefulness for Training	1	2	3	4	5
Realism for training	1	2	3	4	5
Anatomic reality	1	2	3	4	5

For the cadaver lower extremity, please provide feedback on the following:

What are the strengths of the model?

What are the weaknesses?

Did you find anything about the model distracting?

Do you have suggestions for improvement?

Any other comments?

Thank you for your participation!

RASP Study Participant Information

Demographic Information

Name _____ Age _____ Sex _____

Institution _____ Clinical years _____

Status (circle one): Resident Chief Resident Fellow (PGY-6__ PGY-7__) Attending

Address _____

Email _____ Phone _____

Surgical Experience

What is your surgical (sub) specialty? _____

Number of months on:

Trauma Service _____ non-trauma Acute Care Service _____

Please estimate the time since you last performed surgery: Years ____ Months ____ Days ____

Please give the approximate number of patients for each of the following:

Trauma patients you have treated or evaluated _____

Percentage of trauma patients with penetrating trauma _____ %

Estimate the number of trauma-related procedures you have participated in for the following:

1. Upper extremity vascular repairs (open) _____
2. Upper extremity vascular repairs (endovascular) _____
3. Lower extremity vascular repairs (open) _____
4. Lower extremity vascular repairs (endovascular) _____
5. Lower extremity fasciotomy _____

Estimate the number of non-trauma related procedures you have participated in for the following:

1. Upper extremity vascular procedures for dialysis access _____
2. Other upper extremity non-dialysis vascular procedures _____
3. Lower extremity open vascular procedures _____
4. Lower extremity endovascular procedures _____
5. Lower extremity fasciotomy _____

Other than anatomy laboratory during medical school, please estimate the number of hours you have spent in a cadaver laboratory: _____

Have you taken any cadaver based courses since medical school? ____Yes ____No

If yes, please specify: _____

Estimate the amount of time you have spent in a skills laboratory during your training or in other activities:

Minimally Invasive skills tasks: _____ hours

Open operative skills tasks: _____ hours

Evaluation of Surgical Confidence (Pre-ASSET training)

Please indicate the number that best represents your confidence level for your understanding of the surgical anatomy in the following regions:

1	2	3	4	5
No confidence.				Quite a lot of confidence.

Shoulder /axillary region:	1	2	3	4	5
The arm:	1	2	3	4	5
The forearm:	1	2	3	4	5
The inguinal region:	1	2	3	4	5
The lower extremity:	1	2	3	4	5

Please indicate the number that best represents your comfort level with performing each of the following surgical procedures for traumatic injury *independently*.

1	2	3	4	5
No confidence. I would need significant guidance		My confidence wavers with this procedure. I would like supervision.		Quite a lot of confidence. I am sure of what I am doing,

Exposure of major vasculature in the shoulder region:	1	2	3	4	5
Exposure of major vasculature in the arm:	1	2	3	4	5
Exposure of major vasculature in the forearm:	1	2	3	4	5
Exposure of major vasculature in the inguinal region:	1	2	3	4	5
Performance of a lower extremity fasciotomy:	1	2	3	4	5

Evaluation of Surgical Confidence (After evaluation)

Please indicate the number that best represents your confidence level for your understanding of the surgical anatomy in the following regions:

1	2	3	4	5
No confidence.				Quite a lot of confidence.

Shoulder /axillary region: 1 2 3 4 5

The arm: 1 2 3 4 5

The forearm: 1 2 3 4 5

The inguinal region: 1 2 3 4 5

The lower extremity: 1 2 3 4 5

Please indicate the number that best represents your comfort level with performing each of the following surgical procedures for traumatic injury *independently*.

1	2	3	4	5
No confidence. I would need significant guidance		My confidence wavers with this procedure. I would like supervision.		Quite a lot of confidence. I am sure of what I am doing,

Exposure of major vasculature in the shoulder region: 1 2 3 4 5

Exposure of major vasculature in the arm: 1 2 3 4 5

Exposure of major vasculature in the forearm: 1 2 3 4 5

Exposure of major vasculature in the inguinal region: 1 2 3 4 5

Performance of a lower extremity fasciotomy: 1 2 3 4 5

Abstract Detail



Abstract ID **ASC20150892**

Title Management of Vascular Trauma by Senior Surgical Residents: Perception Does Not Equal Reality.

Authors and Affiliations Primary Author - **Mark. W. Bowyer**, MD ¹
Additional Author - **Stacy. A. Shackelford**, ^{1,2}
Additional Author - **Evan. Garofalo**, ^{1,2}
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Classifications	Type	Education
	Scientific Area	Resident Education
	Clinical Area	Trauma/Critical Care

Conflict of Interest Declarations Off Label Use: No

Introduction: Experience with the management of vascular trauma by senior surgical residents is limited. When queried about their understanding of anatomy and ability to perform specific vascular exposures, residents express a moderately high level of confidence. We hypothesized that this perception does not equal reality.

Methods: 42 senior surgical residents participating in an ongoing validation study of the Advanced Surgical Skills for Exposures in Trauma (ASSET) course were asked to self-assess their baseline (pre-course) confidence of their understanding of the anatomy required to perform, and their ability to perform exposures of the Axillary (AA), Brachial (BA), and Femoral (FA) Arteries, as well as Lower Extremity Fasciotomy (LEF) using a 5 point Likert scale. The residents then performed the 4 procedures on a cadaver model and were scored in real time by pre-trained trauma experts using both a global assessment (5 point Likert scale) of "understanding of anatomy" and "resident is ready to perform", as well an overall numerical score (1-100) of the performance. Statistical analysis was performed

Abstract

using the student t-test with α set at $p < 0.05$.

Results: As seen in the table, residents consistently rated their understanding of anatomy and their ability to perform the 4 procedures higher than the expert evaluators ultimately scored them. This was especially pronounced for the lower extremity for both FA exposure and fasciotomy. The average global numerical scores for the 4 procedures was between 57 and 66 out of 100 points.

Conclusion: The findings suggest that senior residents are ill-prepared to perform the studied exposures for vascular trauma, and that they have an unwarranted confidence in both their understanding of the anatomy and the ability to perform these procedures. Perception clearly does meet reality in preparing these trainees to perform as advertised, and future curricular offerings and evaluation should address this gap.

table-1E665500-C45A-0E05-1EF163CEE8757790.jpg - RESIZED for display only

Exposure	Understanding of Anatomy			Ability to Perform Exposure		
	Resident	Expert	p-value	Resident	Expert	p-value
AA	2.50 +/- .83	1.84 +/- .85	< 0.005	2.14 +/- .74	1.84 +/- .75	< 0.18
BA	2.60 +/- .85	2.00 +/- .83	< 0.018	2.40 +/- .76	2.16 +/- .87	< 0.30
FA	3.58 +/- .70	2.75 +/- .54	<0.0004	3.35 +/- .78	2.22 +/- .75	< 2.8 x 10 ⁻⁸
LEF	3.21 +/- .77	1.91 +/- .38	< 2.8 x 10 ⁻⁸	3.02 +/- .89	1.78 +/- .52	< 2.8 x 10 ⁻⁸

Journal of Trauma and Acute Care Surgery

Development and Validation of Trauma Surgical Skills Metrics: Preliminary Assessment of Performance after Training

--Manuscript Draft--

Manuscript Number:	EAST-2014-132R1
Full Title:	Development and Validation of Trauma Surgical Skills Metrics: Preliminary Assessment of Performance after Training
Article Type:	Original Article
Section/Category:	2015 EAST Podium Paper
Keywords:	Surgical skills assessment; ASSET course; Trauma Readiness Index
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Feb 6, 2015

Dear Dr. Moore,

Re: Development and Validation of Trauma Surgical Skills Metrics: Preliminary Assessment of Performance after Training

Please find the attached revised manuscript in response to the reviewers' comments.

Overall novelty/interest of the research question:

Reviewer #1: Innovative study.

Reviewer #2: Multiple new training techniques, ideas, and modalities have been proposed for surgical education. Many of them have not been validated. This is a good first step for the evaluation of a surgical training methodology.

Response: Thank you for comments, no response needed.

Coherence and completeness of background:

Reviewer #1: Concise and coherent.

Reviewer #2: Reference could be made to the need for new teaching methodologies in light of work our restrictions and etc. however overall this is complete.

Response: Thank you. Our intent was to highlight new simulation training methods as alternative teaching methodologies given work hour restrictions.

Hypothesis/study objective clarity:

Reviewer #1: Clearly stated.

Reviewer #2: Clear and concise

Response: Thank you for comments, no response needed.

Adequacy of methods/approach:

Reviewer #1: Thoroughly explained.

Reviewer #2: Excellent

Response: Thank you for comments, no response needed.

Interpretation of data:

Reviewer #1: Appropriate data interpretation.

Reviewer #2: [No response]

Response: Thank you for comments, no response needed.

Conclusion/translatable message:

Reviewer #1: Appropriate conclusion.

Reviewer #2: This surgical education modality significantly improves technical and cognitive/technical ability in the fields studied.

Response: Thank you for comments, no response needed.

Clarity of presentation/organization:

Reviewer #1: Clear and effective presentation.

Reviewer #2: Clear.

Response: Thank you for comments, no response needed.

Additional comments to author:

Reviewer #1:

Interesting, novel and well-designed study. I only have a couple questions for the authors. With a very small group of novice surgeons studied, do you believe your conclusions will hold true with a greater sample size? Please comment. What are your plans for future study with a larger sample size?

Do you think the findings and improvements in time to vascular control will translate to the clinical arena where physiologic variability, severity of injury, and associated injuries may affect technical performance and surgeon judgement?

You have nicely demonstrated improvements in knowledge and technical performance following the ASSET course. However, the real questions, especially for deploying surgeons, are if and how well the improvements are sustained and maintained. Please expand on these questions and their importance in the discussion and in regard to the design of future studies.

Overall, this study is a valuable addition to the literature for surgical education.

Reviewer #2: [No response]

Response: The following comments have been added to the discussion to address the questions

relating to realism/translation and future studies:

“Our aim is to quantify the characteristics of an expert surgeon’s performance as a standard of comparison for other surgeons. We have made the assumption that the expert trauma surgeons, who formed the standard for comparison in this study, perform at a high level in the clinical environment, however such actual clinical performance has never been quantified for emergency procedures. Admittedly, the performance of vascular exposures in a calm laboratory environment with normal anatomy unobscured by active bleeding and anatomic distortion will not translate to success in the clinical arena, however, the vascular exposure represents a fundamental skill for trauma surgery that can be objectively assessed. We have demonstrated quantifiable differences after a training intervention using a score based on the performance of experts.

This study represents the assessments of a pilot group of surgeons and the initial development of a Trauma Readiness Index. Ongoing study in this project will incorporate a larger sample size of surgeons with various levels of experience and longitudinal assessments at various lengths of time, up to five years, after standardized training.”

Sincerely,

Stacy Shackelford, MD, FACS

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Tel: 410-328-0398; fax: 410-328-7549

Background: Maintaining trauma specific surgical skills is an ongoing challenge for surgical training programs. An objective assessment of surgical skills is needed. We hypothesized that a validated surgical performance assessment tool could detect differences following a training intervention.

Methods: We developed surgical performance assessment metrics based on discussion with expert trauma surgeons, video review of 10 experts and 10 novice surgeons performing three vascular exposure procedures and lower extremity fasciotomy on cadavers, and validated the metrics with inter-rater reliability testing by 5 reviewers blinded to level of expertise, and a consensus conference. We tested these performance metrics in 12 surgical residents (year 3-7) before and 2 weeks after vascular exposure skills training in the Advanced Surgical Skills for Exposure in Trauma (ASSET) course. Performance was assessed in three areas: knowledge (anatomic, management), procedure steps, and technical skills. Time to completion of procedures was recorded and these metrics were combined into a single performance score, the Trauma Readiness Index (TRI). Wilcoxon matched-pairs signed-ranks test compared pre/post training effects.

Results: Mean time to complete procedures decreased 4.3 minutes (13.4 to 9.1 min). The performance component most improved by 1-day skills training was procedure steps, completion of which increased 21%. Technical skill scores improved 12%. Overall knowledge improved 3%, with 18% improvement in anatomic knowledge. TRI increased significantly from 50% to 64% with ASSET training. Inter-rater reliability of the surgical performance assessment metrics was validated with single ICC 0.7-0.98.

Conclusion: A trauma-relevant surgical performance assessment detected improvements in specific procedure steps and anatomic knowledge taught during a 1-day course,

quantified by the Trauma Readiness Index. ASSET training reduced time to complete vascular control by one third. Future applications include assessing specific skills in a larger surgeon cohort, assessing military surgical readiness, and quantifying skill degradation with time since training.

DEVELOPMENT AND VALIDATION OF TRAUMA SURGICAL SKILLS METRICS: PRELIMINARY ASSESSMENT OF PERFORMANCE AFTER TRAINING

Short Title: Trauma Surgical Skills Metrics

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Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the US Army, US Air Force, the Department of Defense, or the U.S. Government.

BACKGROUND

Trauma surgical training remains a core competency of general surgery residencies, however opportunities to train and develop trauma specific surgical skills have decreased over the past decade. A number of factors have combined to reduce the total operative trauma cases for graduating chief residents, including a gradual shift in management strategies for traumatic injuries with increased non-operative management,¹⁻³ a shift in the epidemiology of traumatic injury with reduced penetrating trauma nationwide,⁴ and implementation of work hour restrictions since 2003.^{5,6}

Simultaneously, advances in simulation training have occurred, offering a potential mechanism to supplement surgical skills training. Simulation training options include virtual reality trainers,⁷⁻¹⁰ models or manikins,¹¹⁻¹³ human cadaver training,¹⁴⁻¹⁶ and animal laboratories.¹⁷⁻²⁰ A number of surgical skills assessment methods have been developed over the past decade that include the general categories of task-specific checklists, global rating scales, procedure-specific rating scales, and non-technical skills assessments.²¹⁻²³ An objective method of assessing competency in surgical skills specific to trauma surgery would be very beneficial to surgical training programs. Military surgeons are faced with the additional challenge of maintaining trauma specific surgical skills necessary for wartime deployments. Routine trauma care is not provided in the daily practice of most military surgeons,²⁴ so that interval assessment of trauma specific surgical skills over time is needed to ensure that previously trained surgeons remain prepared for deployment.

Our objective for this study was to develop a construct- and face-validated method²³ for evaluating a surgeon's performance of four procedures that are important in

the management of traumatic injuries. We hypothesized that such a surgical performance assessment method could detect knowledge and skill differences following a training intervention.

METHODS

The studies described in this paper were approved by the University of Maryland School of Medicine Institutional Review Board, the Maryland State Anatomy Board, and the US Army Office of Research Protection for research involving humans, human data, human specimens, or cadavers. Surgeon research subjects underwent a consent process and completed informed consent before participation.

Metrics Development

Four expert surgeons were interviewed regarding important knowledge of four procedures: exposures of the axillary artery, brachial artery, and femoral artery and lower extremity fasciotomy. The procedures were chosen as representative of those used for vascular exposure for trauma since these are important techniques for rapid control of hemorrhage. Lower extremity fasciotomy is an important procedure to reduce morbidity associated with lower extremity injury.

The experts discussed patient management and decision-making strategies relating to each of the procedures and described the landmarks, structures, common errors and complications that might occur. On a separate occasion, 10 expert trauma surgeons (fellowship trained, 2-40 years in practice, including the original four experts interviewed) performed the procedures on fresh cadavers and were audio-video-recorded. Audio-video data were captured with use of both an overhead pan-tilt zoom camera and a miniature camera mounted on the surgeons' head to allow for later review and analysis.

Cognitive work analysis methodology was used, including so-called process-tracing, that is the recording of both “thinking out loud” and more structured didactics provided by experts while performing the procedures.²⁵⁻²⁷ The expert surgeons were asked to provide commentary and teaching points as though they were demonstrating to medical students while performing the procedures in the operating room. These structured and unstructured observations were used to capture and provide a platform for developing metrics that describe the complexity of individual expert performance.

Consensus Conference

A consensus conference was then convened including two experienced trauma surgeons, a non-surgeon trauma clinician/researcher, and two human anatomists to develop procedure specific performance metrics through review of videos of expert performance. Previously described metrics such as Objective Structured Assessment of Technical Skill,²⁸ Procedure Based Assessment,²⁹ and orthopaedic competence evaluation³⁰ were considered. Surgical technical skills assessment metrics were selected that best captured the key components of an expert trauma surgeon’s performance of these four surgical procedures.

Script and Scoring

The script included instructions, case histories, and scoring developed for each procedure in this study, with questions and a score sheet covering knowledge of patient management, including procedure steps and technical skills. Anatomic knowledge and procedure steps scores were binary yes/no answers for each knowledge response or step of the procedure, and surgical technique was evaluated on a Likert scale for each of 10 identified technical skills. (Table 1) The scoring process was developed based on review

of expert commentary made during performance of that procedure (essential responses or actions received 2 points, additional knowledge received 1 point, errors received -2 points if uncorrected and -1 point if recognized and corrected). The script was read out loud during the evaluation. Questions and instructions were repeated once, if needed, but no prompting or further instruction was provided to the participating surgeons.

Evaluator Training and Inter-Rater Reliability Testing

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Evaluating Surgeons Before and After ASSET Training (Phase 2)

As preliminary proof-of-concept, we tested surgical performance metrics with single ICC > 0.70 in 12 surgical trainees (Phase 2: residents and fellows, clinical year of training 3-7, none of whom participated in the earlier evaluations) before and within 2 weeks after vascular exposure surgical skills training carried out by instructors for the

Advanced Surgical Skills for Exposure in Trauma (ASSET) course. The ASSET course is an American College of Surgeons-approved human cadaver-based 1-day skills course that systematically reviews all of the major vascular exposures in the body, emphasizing that vascular exposure is the requisite first step in achieving control of major hemorrhage.¹⁴ ASSET course content includes the 4 procedures evaluated in this study among a total of 47 procedures taught during the course.

Surgical performance of the 12 surgeons was assessed by pairs of trained evaluators, with one surgeon and one non-surgeon investigator assessing each surgeon subject's performance. Data on surgeon responses to knowledge questions and technical performance were captured during the procedures by completion of the responses and scores integrated into the script. A maximum of twenty minutes was allowed for the completion of each of the four procedures. For each surgeon, scores were calculated in each area of assessment (overall knowledge, anatomic knowledge, patient management knowledge, procedure steps, and technique points) as a percentage of total available points. To provide a discrete metric to identify "readiness" to perform these procedures, the Trauma Readiness Index (TRI) was then calculated as the sum of points awarded for all four procedures and remaining time allowed divided by the sum of possible points and time allowed. Statistical analysis for surgical performance of Phase 2 residents, evaluated by two real-time evaluators before and after ASSET course training, was compared with a Wilcoxon matched-pairs signed rank test ($\alpha=0.05$).

RESULTS

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The evaluation scores of the Phase 1 novice surgeons were calculated in the manner described above for the axillary artery, brachial artery, and femoral artery exposures, and lower extremity fasciotomy procedures. The surgeons' mean knowledge score for all procedures reached 58 percent of idealized performance. Questions specifically addressing anatomic and management knowledge had a mean score of 54 and 46 percent, respectively. Phase 1 novice surgeons performed a mean of 43 percent of the procedure steps correctly and were awarded 48 percent of the possible expert technical skills points. The mean Trauma Readiness Index score for all procedures was 50 percent. Scores for each procedure are detailed in Table 2. In a single sample t-test, all of these scores differentiate significantly from idealized performance (100 percent, $p < 0.001$). The average time to complete each procedure was 16.8 minutes.

Comparison of Surgical Skills Before and After ASSET training (Phase 2)

Twelve surgeons were evaluated using the knowledge questions, procedure-based checklists, and 4 validated technical skills before and after ASSET training. The difference in pre- and post-training scores is illustrated in figure 1.

The mean time for completion of each of the four specific procedures decreased significantly from 13.4 minutes before training to 9.1 minutes after training ($p<0.001$).

Surgical trainees assessed at baseline before ASSET training achieved an average of 50 percent of the idealized expert surgeon performance score for overall knowledge, 46 percent for procedure steps, and 60 percent for technical skills.

After completing the ASSET course, the specific skill most improved by the 1-day skills course was procedure steps, which improved by 21 percent after training. Anatomic knowledge was also strongly impacted by training, with 18 percent increase in mean scores for this metric. A 12 percent improvement in technical skill scores occurred after training, although technical skills were not specifically emphasized during the training. No improvement in patient management knowledge was detected, a field not addressed by the training. The Trauma Readiness Index was 50 percent of the expert surgeon performance before training and was improved by 14 percent after training. Pre and post-training scores are displayed in Table 3.

The cost involved in the assessments was modest (about \$ 2,500 per enrolled surgeon, including cadavers, laboratory and evaluator fees, and travel costs).

DISCUSSION

This study developed validated surgical performance metrics for assessment of vascular control procedures and lower extremity fasciotomy. Since vascular exposure procedures are used to stop bleeding and it is reasonable to expect that more rapid vascular control will reduce blood loss in trauma patients, it is notable that ASSET training reduced time to successful vascular control by one third. We included the time to perform each procedure as an important component of the Trauma Readiness Index.

Not surprisingly, knowledge of the local anatomy of each procedure closely correlated with decreased time to perform the vascular exposures. These analyses support the use of the ASSET course to improve a surgeon's technical skills for trauma.

We were interested to find that technical skills improved by 12 percent following the ASSET course. Since such technical skills are not specifically taught during the course and are normally acquired through years of training and experience, we believe that the improvement seen in this assessment reflects an improvement in anatomic and procedure-specific knowledge that allowed surgeons to complete each procedure more quickly and confidently. This illustrates the complex nature of surgical skills and the interrelated influence of knowledge and technical skill.

The Trauma Readiness Index also includes additional knowledge assessment focusing on disease processes such as hemorrhagic shock, ischemia reperfusion injury, and compartment syndrome along with patient management knowledge to include damage control resuscitation, rhabdomyolysis, etc. These knowledge questions were categorized as patient management knowledge. Such knowledge, which is normally acquired through diligent study during the course of surgical training, was not improved by the ASSET course.

Important to this assessment method was the selection of four procedures to represent overall trauma-related knowledge and technical skill. Although management of critically injured patients requires a wide variety of skills, the three vascular exposure procedures were selected because they are performed with relative infrequency in trauma patients and may therefore represent a fairly advanced level of trauma-specific knowledge, while at the same time requiring certain technical skills that are common to

all types of vascular control maneuvers. Lower extremity fasciotomy was included because it is an important trauma-related procedure not frequently performed during general surgery residency training that is also taught during the ASSET course. The military has also identified incomplete fasciotomy as a significant source of morbidity in trauma patients evacuated from theaters of war, and is therefore an important training requirement for deploying military surgeons.³² Procedure-specific checklists have been developed for many procedures, and share the common weakness that a separate checklist is required for each procedure and the quality of performance is not assessed.²¹ We included procedure-specific checklists as an important component of the Trauma Readiness Index because we believe it is imperative to ensure that the ultimate objective of each vascular control procedure and fasciotomy is evaluated as an endpoint. Further, we theorized that it is not necessary to specifically evaluate every possible vascular control maneuver, but that careful selection of representative procedures will provide an adequate representation of surgical performance. Procedure specific checklists can be developed for additional vascular exposure procedures with relative ease by using the current script as a template.

The design of the study met recommended parameters for a study of surgical technical skills, including content and face validity, and was validated with construct validity, inter rater reliability and concurrent validity. The implementation of this assessment method is feasible and reasonably cost effective.²³ The educational impact of training using the ASSET course was captured with the Trauma Readiness Index for trauma specific vascular exposure skills and fasciotomy, detecting improvements in anatomic knowledge, completion of specific procedure steps, and surgical technical

skills. The Trauma Readiness Index may also be a valuable tool for assessing knowledge gained through the course of residency or pre-deployment training for surgeons.

The Trauma Readiness Index surgical performance assessment method was modeled after previously developed surgical skills assessment tools,^{21, 28-30, 33} and incorporates a variety of assessments to achieve an overall measurement of knowledge and skills important for management of trauma patients, including knowledge questions, procedure-specific checklists, and global rating scales that are based on observation of expert performances. The Trauma Readiness Index provides an objective assessment of a surgeon's readiness to perform trauma resuscitation and surgical procedures, in particular control of extremity hemorrhage and fasciotomy. The tool is limited in its ability to assess nontechnical skills important in team management and performance in a potentially chaotic trauma resuscitation environment. The evaluation metric scores, including the Trauma Readiness Index, show no floor or ceiling effects suggesting they would be useful to test adequacy of surgeon's performance with different levels of expertise. We found, as have others,²¹ that capturing the full range of surgical performance, from novice to expert, required the use of global rating scales. Such global rating scales evaluate the quality of overall technical skills that are not specific to any particular procedure, capturing skills such as proper handling of blood vessels and economy of movement. An experienced evaluator is required to assess such skills; certainly an experienced surgeon of the same specialty will be able to perform such an assessment; however it is likely that properly trained evaluators, including non-surgeons, will also be able to accurately assess a surgeon's technical skills using the validated skills metrics.

The fresh cadaver has limitations in realism and fidelity that were identified by the participants in this study, including lack of bleeding, lack of real injuries with associated hematoma and tissue distortion, as well as differences in body tissue mechanics. These differences may have impacted the performance of the technical skills and their assessments.

Our aim is to quantify the characteristics of an expert surgeon's performance as a standard of comparison for other surgeons. We have made the assumption that the expert trauma surgeons, who formed the standard for comparison in this study, perform at a high level in the clinical environment, however such actual clinical performance has never been quantified for emergency procedures. Admittedly, the performance of vascular exposures in a calm laboratory environment with normal anatomy unobscured by active bleeding and anatomic distortion will not translate to success in the clinical arena, however, the vascular exposure represents a fundamental skill for trauma surgery that can be objectively assessed. We have demonstrated quantifiable differences after a training intervention using a score based on the performance of experts.

This study represents the assessments of a pilot group of surgeons and the initial development of a Trauma Readiness Index. Ongoing study in this project will incorporate a larger sample size of surgeons with various levels of experience and longitudinal assessments at various lengths of time, up to five years, after standardized training.

CONCLUSION

A trauma-specific surgical knowledge and performance assessment tool with content and face validity was validated for three vascular control procedures and lower

extremity fasciotomy. ASSET training reduced time to vascular control by one third. The Trauma Readiness Index detected improvements in anatomic knowledge, completion of specific procedure steps, and surgical technical skills after training with a 1-day course. This Trauma Readiness Index assessment method could be used in skills courses, general surgery residency, trauma fellowship, or military pre-deployment training to show competency. Future applications will include assessing specific skills acquired during the course of residency training, assessing military surgical readiness, and quantifying skill degradation with time since training.

Author Contributions: *SS and CFM:* literature search, study design, data collection, data analysis and interpretation, writing and critical revisions; *EG:* literature search, data collection, data analysis and interpretation, writing and critical revisions. *HC:* study design, statistical analyses; *VS:* literature search, study design, data interpretation; *KP:* literature search, data collection; *JP, BS, SH:* data collection, data interpretation, critical revisions; *MB* study design; data collection, data analysis and interpretation, and critical revisions.

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BACKGROUND

Trauma surgical training remains a core competency of general surgery residencies, however opportunities to train and develop trauma specific surgical skills have decreased over the past decade. A number of factors have combined to reduce the total operative trauma cases for graduating chief residents, including a gradual shift in management strategies for traumatic injuries with increased non-operative management,¹⁻³ a shift in the epidemiology of traumatic injury with reduced penetrating trauma nationwide,⁴ and implementation of work hour restrictions since 2003.^{5,6}

Simultaneously, advances in simulation training have occurred, offering a potential mechanism to supplement surgical skills training. Simulation training options include virtual reality trainers,⁷⁻¹⁰ models or manikins,¹¹⁻¹³ human cadaver training,¹⁴⁻¹⁶ and animal laboratories.¹⁷⁻²⁰ A number of surgical skills assessment methods have been developed over the past decade that include the general categories of task-specific checklists, global rating scales, procedure-specific rating scales, and non-technical skills assessments.²¹⁻²³ An objective method of assessing competency in surgical skills specific to trauma surgery would be very beneficial to surgical training programs. Military surgeons are faced with the additional challenge of maintaining trauma specific surgical skills necessary for wartime deployments. Routine trauma care is not provided in the daily practice of most military surgeons,²⁴ so that interval assessment of trauma specific surgical skills over time is needed to ensure that previously trained surgeons remain prepared for deployment.

Our objective for this study was to develop a construct- and face-validated method²³ for evaluating a surgeon's performance of four procedures that are important in

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4 the management of traumatic injuries. We hypothesized that such a surgical performance
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6 assessment method could detect knowledge and skill differences following a training
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8 intervention.
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10 11 **METHODS** 12

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14 The studies described in this paper were approved by the University of Maryland
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16 School of Medicine Institutional Review Board, the Maryland State Anatomy Board, and
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18 the US Army Office of Research Protection for research involving humans, human
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20 data, human specimens, or cadavers. Surgeon research subjects underwent a
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22 consent process and completed informed consent before participation.
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25 26 **Metrics Development** 27

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29 Four expert surgeons were interviewed regarding important knowledge of four
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31 procedures: exposures of the axillary artery, brachial artery, and femoral artery and lower
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33 extremity fasciotomy. The procedures were chosen as representative of those used for
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35 vascular exposure for trauma since these are important techniques for rapid control of
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37 hemorrhage. Lower extremity fasciotomy is an important procedure to reduce morbidity
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39 associated with lower extremity injury.
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43 The experts discussed patient management and decision-making strategies
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45 relating to each of the procedures and described the landmarks, structures, common errors
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47 and complications that might occur. On a separate occasion, 10 expert trauma surgeons
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49 (fellowship trained, 2-40 years in practice, including the original four experts
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51 interviewed) performed the procedures on fresh cadavers and were audio-video-recorded.
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53 Audio-video data were captured with use of both an overhead pan-tilt zoom camera and a
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55 miniature camera mounted on the surgeons' head to allow for later review and analysis.
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Cognitive work analysis methodology was used, including so-called process-tracing, that is the recording of both “thinking out loud” and more structured didactics provided by experts while performing the procedures.²⁵⁻²⁷ The expert surgeons were asked to provide commentary and teaching points as though they were demonstrating to medical students while performing the procedures in the operating room. These structured and unstructured observations were used to capture and provide a platform for developing metrics that describe the complexity of individual expert performance.

Consensus Conference

A consensus conference was then convened including two experienced trauma surgeons, a non-surgeon trauma clinician/researcher, and two human anatomists to develop procedure specific performance metrics through review of videos of expert performance. Previously described metrics such as Objective Structured Assessment of Technical Skill,²⁸ Procedure Based Assessment,²⁹ and orthopaedic competence evaluation³⁰ were considered. Surgical technical skills assessment metrics were selected that best captured the key components of an expert trauma surgeon’s performance of these four surgical procedures.

Script and Scoring

The script included instructions, case histories, and scoring developed for each procedure in this study, with questions and a score sheet covering knowledge of patient management, including procedure steps and technical skills. Anatomic knowledge and procedure steps scores were binary yes/no answers for each knowledge response or step of the procedure, and surgical technique was evaluated on a Likert scale for each of 10 identified technical skills. (Table 1) The scoring process was developed based on review

of expert commentary made during performance of that procedure (essential responses or actions received 2 points, additional knowledge received 1 point, errors received -2 points if uncorrected and -1 point if recognized and corrected). The script was read out loud during the evaluation. Questions and instructions were repeated once, if needed, but no prompting or further instruction was provided to the participating surgeons.

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43 **DISCUSSION**

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37 categorized as patient management knowledge. Such knowledge, which is normally
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39 acquired through diligent study during the course of surgical training, was not improved
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41 by the ASSET course.
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46 Important to this assessment method was the selection of four procedures to
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48 represent overall trauma-related knowledge and technical skill. Although management of
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50 critically injured patients requires a wide variety of skills, the three vascular exposure
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52 procedures were selected because they are performed with relative infrequency in trauma
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54 patients and may therefore represent a fairly advanced level of trauma-specific
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56 knowledge, while at the same time requiring certain technical skills that are common to
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all types of vascular control maneuvers. Lower extremity fasciotomy was included because it is an important trauma-related procedure not frequently performed during general surgery residency training that is also taught during the ASSET course. The military has also identified incomplete fasciotomy as a significant source of morbidity in trauma patients evacuated from theaters of war, and is therefore an important training requirement for deploying military surgeons.³² Procedure-specific checklists have been developed for many procedures, and share the common weakness that a separate checklist is required for each procedure and the quality of performance is not assessed.²¹ We included procedure-specific checklists as an important component of the Trauma Readiness Index because we believe it is imperative to ensure that the ultimate objective of each vascular control procedure and fasciotomy is evaluated as an endpoint. Further, we theorized that it is not necessary to specifically evaluate every possible vascular control maneuver, but that careful selection of representative procedures will provide an adequate representation of surgical performance. Procedure specific checklists can be developed for additional vascular exposure procedures with relative ease by using the current script as a template.

The design of the study met recommended parameters for a study of surgical technical skills, including content and face validity, and was validated with construct validity, inter rater reliability and concurrent validity. The implementation of this assessment method is feasible and reasonably cost effective.²³ The educational impact of training using the ASSET course was captured with the Trauma Readiness Index for trauma specific vascular exposure skills and fasciotomy, detecting improvements in anatomic knowledge, completion of specific procedure steps, and surgical technical

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4 skills. The Trauma Readiness Index may also be a valuable tool for assessing knowledge
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6 gained through the course of residency or pre-deployment training for surgeons.
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9 The Trauma Readiness Index surgical performance assessment method was
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11 modeled after previously developed surgical skills assessment tools,^{21, 28-30, 33} and
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13 incorporates a variety of assessments to achieve an overall measurement of knowledge
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15 and skills important for management of trauma patients, including knowledge questions,
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17 procedure-specific checklists, and global rating scales that are based on observation of
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19 expert performances. The Trauma Readiness Index provides an objective assessment of a
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21 surgeon's readiness to perform trauma resuscitation and surgical procedures, in particular
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23 control of extremity hemorrhage and fasciotomy. The tool is limited in its ability to
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25 assess nontechnical skills important in team management and performance in a
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27 potentially chaotic trauma resuscitation environment. The evaluation metric scores,
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29 including the Trauma Readiness Index, show no floor or ceiling effects suggesting they
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31 would be useful to test adequacy of surgeon's performance with different levels of
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33 expertise. We found, as have others,²¹ that capturing the full range of surgical
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35 performance, from novice to expert, required the use of global rating scales. Such global
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37 rating scales evaluate the quality of overall technical skills that are not specific to any
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39 particular procedure, capturing skills such as proper handling of blood vessels and
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41 economy of movement. An experienced evaluator is required to assess such skills;
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43 certainly an experienced surgeon of the same specialty will be able to perform such an
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45 assessment; however it is likely that properly trained evaluators, including non-surgeons,
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47 will also be able to accurately assess a surgeon's technical skills using the validated skills
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49 metrics.
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4 The fresh cadaver has limitations in realism and fidelity that were identified by
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6 the participants in this study, including lack of bleeding, lack of real injuries with
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8 associated hematoma and tissue distortion, as well as differences in body tissue
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10 mechanics. These differences may have impacted the performance of the technical skills
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12 and their assessments.
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16 Our aim is to quantify the characteristics of an expert surgeon's performance as a
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18 standard of comparison for other surgeons. We have made the assumption that the expert
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20 trauma surgeons, who formed the standard for comparison in this study, perform at a high
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22 level in the clinical environment, however such actual clinical performance has never
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24 been quantified for emergency procedures. Admittedly, the performance of vascular
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26 exposures in a calm laboratory environment with normal anatomy unobscured by active
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28 bleeding and anatomic distortion will not translate to success in the clinical arena,
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30 however, the vascular exposure represents a fundamental skill for trauma surgery that can
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32 be objectively assessed. We have demonstrated quantifiable differences after a training
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34 intervention using a score based on the performance of experts.
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41 This study represents the assessments of a pilot group of surgeons and the initial
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43 development of a Trauma Readiness Index. Ongoing study in this project will
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45 incorporate a larger sample size of surgeons with various levels of experience and
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47 longitudinal assessments at various lengths of time, up to five years, after standardized
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49 training.
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52 53 **CONCLUSION** 54

55 A trauma-specific surgical knowledge and performance assessment tool with
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57 content and face validity was validated for three vascular control procedures and lower
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4 extremity fasciotomy. ASSET training reduced time to vascular control by one third. The
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6 Trauma Readiness Index detected improvements in anatomic knowledge, completion of
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8 specific procedure steps, and surgical technical skills after training with a 1-day course.
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10 This Trauma Readiness Index assessment method could be used in skills courses, general
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12 surgery residency, trauma fellowship, or military pre-deployment training to show
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14 competency. Future applications will include assessing specific skills acquired during the
15
16 course of residency training, assessing military surgical readiness, and quantifying skill
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18 degradation with time since training.
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23 **Author Contributions:** *SS and CFM:* literature search, study design, data collection, data
24
25 analysis and interpretation, writing and critical revisions; *EG:* literature search, data
26
27 collection, data analysis and interpretation, writing and critical revisions. *HC:* study
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29 design, statistical analyses; *VS:* literature search, study design, data interpretation; *KP:*
30
31 literature search, data collection; *JP, BS, SH:* data collection, data interpretation, critical
32
33 revisions; *MB* study design; data collection, data analysis and interpretation, and critical
34
35 revisions.
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39

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54 study schedules.
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		ICC	
1	Exposes arteries by dissecting directly on anterior surface	Single	0.5
		Average	0.84
2	Manipulates artery by grasping adventitia	Single	0.2
		Average	0.55
3	Uses instruments properly	Single	0.3
		Average	0.68
4	Positions body to use instruments to best advantage	Single	0.41
		Average	0.78
5	Proceeds at an appropriate pace with economy of movement*	Single	0.8
		Average	0.95
6	Handles tissue well with minimal damage	Single	0.36
		Average	0.74
7	Creates an adequate visual field using retractors for procedure*	Single	0.78
		Average	0.95
8	Communicates clearly and consistently*	Single	0.77
		Average	0.94
9	Performs procedure without unnecessary dissection*	Single	0.72
		Average	0.93
10	Continually progresses toward the end goal	Single	0.69
		Average	0.92
*single ICC > 0.70 metrics included in Trauma Readiness Index			

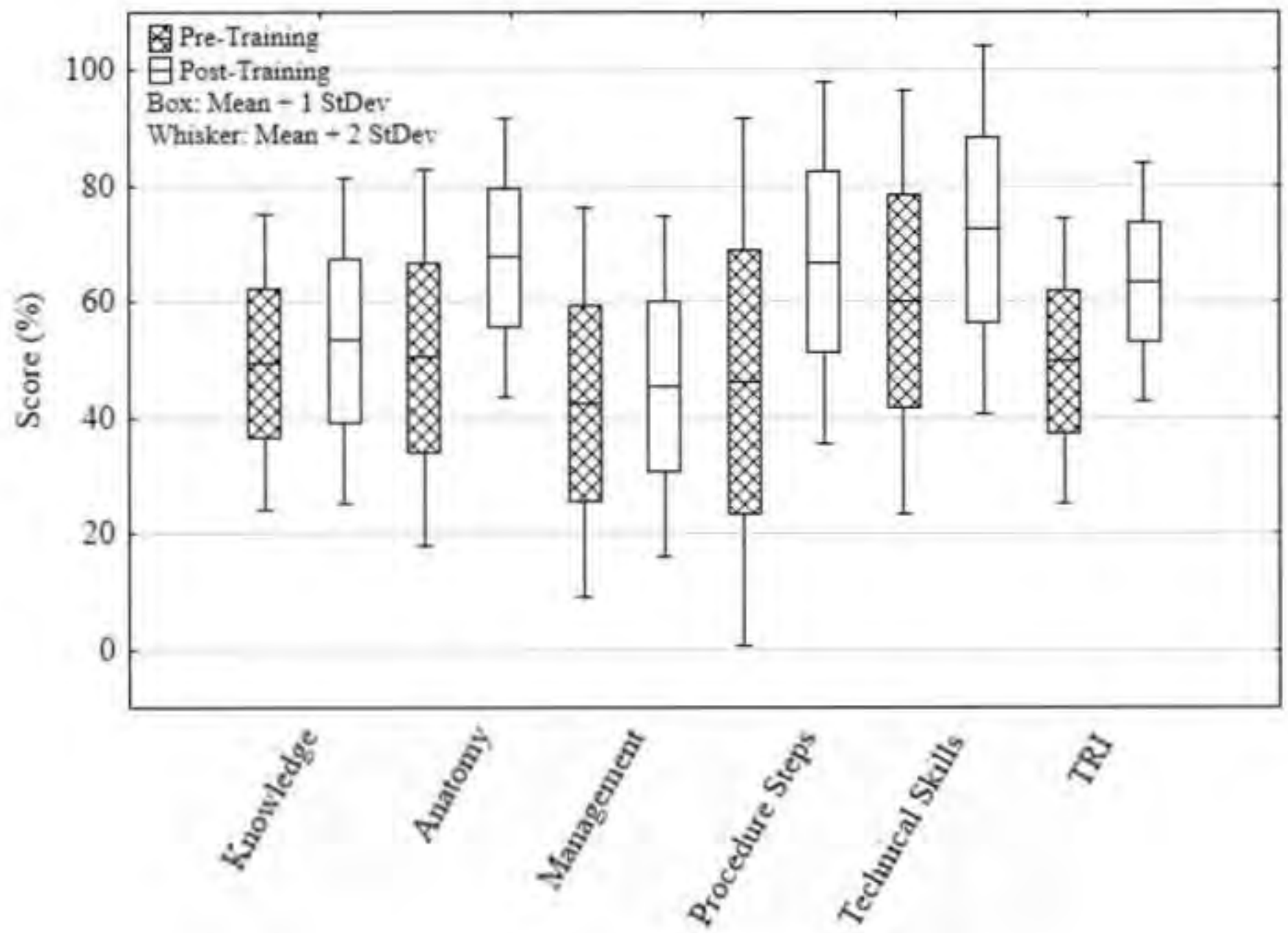
Table 1. Surgeon technical skills with intra-class correlation coefficients (ICC).

	All Four Procedures		Axillary		Brachial		Femoral		Fasciotomy	
	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
Time	16.8	9.4	14.4	14.4	6	20.5	5.3	16.2	8.5	14.4
Knowledge										
• Overall	58	11	50	9	68	11	57	7	56	8
• Anatomic	54	19	58	15	42	20	58	12	58	24
• Management	46	16	37	15	64	12	42	9	42	13
Procedure steps	43	28	48	29	24	28	51	21	49	29
Technical Skills	48	10	56	42	53	39	38	39	40	28
TRI/Procedure score	50	14	49	12	47	18	54	9	52	15

Table 2: Detailed results of Phase 1 novice surgeon scores, n=10 (all are significantly different from idealized performance, 100%, $p<0.001$ in a single sample t-test). TRI, Trauma Readiness Index; St Dev, standard deviation.

	Pre-training		Post-training			
	Mean	Std Dev	Mean	Std Dev	Improvement	<i>p</i> -value
Time (minutes)	13.4	5.9	9.1	4.5	-4.3	<0.001
Knowledge score						
• Overall	50	13	53	14	3	0.013
• Anatomic	50	16	68	12	18	<0.001
• Management	43	17	45	15	2	0.044
Procedure steps score	46	23	67	16	21	<0.001
Technical skills score	60	18	71	17	12	<0.001
Trauma Readiness Index	50	12	64	10	14	<0.001
Scores represent the percentage of idealized expert surgeon performance skills found in surgical trainees.						

Table 3. Surgical Performance Assessment Scores for Phase 2 Surgeons, n=12.



Appendix 11: Mobile Platform to evaluate individual technical skills American Society of Anesthesiologists, October 2014

Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kupper, George Hagegeorge, Peter Hu, Evan Garofalo, Mary Njoku, Stacy Shackelford

Background: Many medical specialty Boards have proposals to include a simulated patient encounter to test technical skills in addition to knowledge-based oral examinations in future certification processes. We developed surgical technical skills assessment metrics based on discussion with expert surgeons, video review of 10 experts performing four procedures, and a consensus conference. We describe the utility of a mobile app and video/audio capture system that was used to gather data and results of testing such surgical technical skills metrics, as the principles have widespread applicability for evaluation of anesthesiology training and realtime clinical management, as well as for telemedicine and research applications.

Methods: After Institutional Review Board approvals, an audio-video data capture system was tested during four surgical procedures performed on both cadavers and hyper-realistic physical models by 10 residents. Software was developed for Android tablets to capture assessments of knowledge (indications, complications) and technical skills (10 specific steps and techniques, 6 technical maneuvers and 5 performance global ratings) common to the 10 experts. Results were uploaded to the cloud for blinded video analysis by 5 trained evaluators and tested with regression modeling and inter-rater reliability (ICC) analysis. We also tested three camera systems (Pan-tilt-zoom [PTZ] ceiling mounted, on mobile stand, head-mounted camera with laser pointer) and three audio capture systems (head worn boom microphone, ceiling mounted and audio capture with head camera).

Results: The tablet facilitates capture of surgeon evaluation metrics with little intrusion and without paper copies. Data from multiple evaluations stored in the cloud avoids data transcription. The \$120 head-mounted laser-directed camera captured 1.5 hours of surgical video and audio adequately to assess performance metrics remotely. The PTZ camera with boom/overhead audio system (\$90K) gave the best image, but was obstructed by the operator's head. The mobile stand mounted camera required constant movement to capture images of the surgical field. Inter-rater reliability (ICC) among technical skills assessments ranged between 0.79-0.98. Among 10 residents, knowledge questions: 62- 93% were answered correctly. Occurrence of 16 expert technical skills were found in 51-59% of residents. Global ratings (median Likert 1-5 and overall %); Technical: 3 overall 54%; Indications/Complications 3 with 81% correct; Anatomy knowledge 3 with 78% correct, Global Evaluation 69%.

Discussion: Using an inexpensive mobile data and video/audio capture system with remotely situated evaluators, performance metrics discriminated experts from novices for technical and non-technical skills with excellent inter-rater reliability. Validation in a larger population and before/after skills training is required. Further work will test the simulated physical models of the four procedures with enough fidelity to realistically challenge technique, to provide a mobile skills evaluation platform. Funded by W81XWH-13-2-0028

Appendix 12: Evaluation of individual surgeon technical skills during four emergency procedures

Podium Presentation: Association of Military Surgeons of US (AMSUS, December 2014)

Colin F Mackenzie, Evan Garofalo, Hegang Chen, Valerie Shalin, Kristy Pugh, Stacy Shackelford, Sharon Henry, Mark Bowyer, Mark Fitzgerald, Joost Funke Kupper, George Hagegeorge, Peter Hu, Kon Mouzakis.

Background: Maintaining trauma specific surgical skills is a challenge for military surgeons. Objective assessment of surgical readiness is needed. We hypothesized that expert surgeon technical skill metrics could provide a reliable technical skill assessment for less experienced surgeons.

Methods: After Institutional Review Board approvals, surgical technical skills assessment metrics were developed from discussion with 10 expert surgeons, video review performing three vascular exposure procedures and lower extremity fasciotomy on both cadavers and hyper-realistic physical models, and a consensus conference. These same metrics were tested in 10 residents using Android tablet software and a head camera to capture 16 specific steps and techniques and 5 performance global ratings during the four procedures. Performance was then assessed on random video-clips of both experts and novices by 5 trained evaluators and compared with regression modeling and inter-rater reliability (ICC) analysis.

Results: Among 10 residents, scores showed no evidence of floor or ceiling effects. Occurrence of 16 expert technical skills, agreed upon by experts, was found in 51-59% of residents during the 4 procedures. Global overall performance rating was 54%. Global technical performance was 69%. ICC ranged from 0.79-0.99 for agreement both between raters and among most skills ratings.

Discussion: Evaluation metrics discriminated novices from an expert standard with excellent inter-rater reliability. Validation in a larger population and before/after skills training is required. Further work with simulated physical models may provide a mobile skills evaluation platform without cadavers.

Support: US Army (USAMRMC) W81XWH-12-JPC1

Appendix 13: Accurate Assessment of Surgical Skill Improvements after Training

Presentation: Eastern Association of Surgery for Trauma (EAST, January 2015)

Stacy Shackelford, MD, Evan Garofalo, PhD, Valerie Shalin, PhD, Kristy Pugh, MS, Jason Pasley, DO, Babak Sarani, MD, Sharon Henry, MD, Mark Bowyer, MD, Colin Mackenzie MBChB

Background: Maintaining trauma specific surgical skills is an ongoing challenge for surgical training programs. An objective assessment of surgical skills is needed. We hypothesized that a reliable surgical skills assessment tool could detect knowledge and skill differences following a training intervention.

Methods: After Institutional Review Board approval, we developed surgical technical skills assessment metrics based on discussion with expert surgeons, video review of 10 experts performing four vascular exposure procedures on both cadavers and hyper-realistic physical models, and a consensus conference. We then tested knowledge and technical skill metrics in 12 surgical residents (year 3-5) before and 2 weeks after vascular exposure skills training with the Advanced Surgical Skills for Exposure in Trauma course. Performance was assessed by six trained evaluators; data was recorded using Android tablet software and a head camera to capture technical skill assessments. Performance was assessed in three areas: knowledge (anatomic, indications, management), procedural steps, and technical skills. Time to completion of procedures was recorded..

Performance scores were calculated before and after training. Wilcoxon paired t was used to examine statistical significance at $\alpha < 0.05$.

Results: Trauma Readiness Index for three vascular exposures and lower extremity fasciotomy improved by 14% after training. Sorted by specific skills, the skill most improved by 1-day skills was procedural steps, scores increased 20%. Technical skill scores improved 12%. Overall knowledge improved 3%, with further analysis localizing this effect to a 17% improvement in anatomic knowledge. Time to complete procedures decreased 4.3 minutes (13.4 to 9.1 min).

Conclusion: A detailed surgical skills assessment is a valuable tool to assess a variety of surgical training programs. The measurement tool detected improvements in specific procedural steps and anatomic knowledge taught during a 1-day course. The tool also detected improvements in technical skills and management normally acquired during the course of residency training. Future applications will include assessing specific skills acquired during the course of residency training.

Surgical Skills Assessment Scores						
	Pre-training		Post-training			
	Mean	Std Dev	Mean	Std Dev	Improvement	P-value
Knowledge score*						
• Overall	50	13	53	14	3	0.013
• Anatomic	50	16	50	16	17	0.00001
• Management	43	17	45	15	2	0.044
Technical skills score*	59	18	71	17	12	0.0001
Procedure steps score*	46	23	67	16	20	0.0000001
Time (minutes)	13.4	5.9	9.1	4.5	-4.3	0.000001
Trauma Readiness Index*	50	12	64	10	14	0.0001
*Scores represent the percentage of expert surgeon performance skills found in residents						



Integrity ★ Service ★ Excellence

Accurate Assessment of Surgical Skill Improvements after Training:

**Development and Validation of
Trauma Surgical Skills
Metrics, Preliminary
Assessment**

Stacy Shackelford, MD,
Evan Garofalo, PhD, Valerie Shalin, PhD,
Kristy Pugh, MS, Hegang Chen, PhD,
Jason Pasley, DO, Babak Sarani, MD,
Sharon Henry, MD, Mark Bowyer, MD,
Colin Mackenzie, MBChB

Faculty Disclosures

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- Support: US Army Medical Research and Materiel Command, Grant #W81XWH-13-20028

Background

- Operative trauma has gradually decreased over the past five decades
 - Prevention
 - Violence outreach programs
 - Law enforcement
 - Non-op treatment of solid organ injuries
 - Interventional radiology advances
- Work hour restrictions for residents—2003
- Operative trauma for graduating chief residents
 - 60.4 cases in 1999
 - 33.5 cases in 2012

Background

- Advances in surgical simulation
 - Virtual reality
 - Animal models
 - Human cadaver



ASSET Course

Advanced Surgical Skills for Exposure in Trauma

- Launched in 2010
- Reviews all major vascular exposures in the body
 - Fasciotomy of upper and lower limb
- First step in achieving control of major hemorrhage

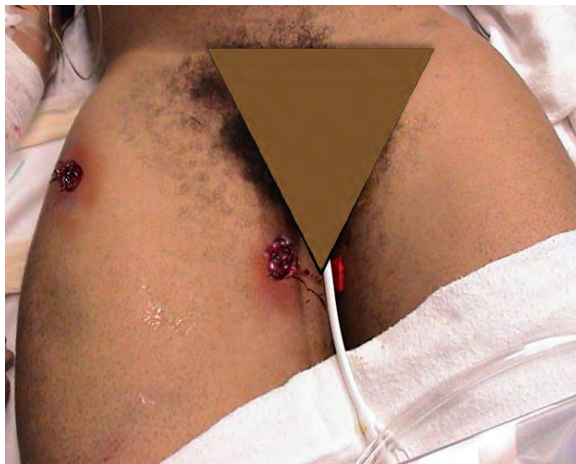


Objective

Develop a validated method for evaluating a surgeon's performance of procedures important in management of traumatic injuries taught during the ASSET course.

Methods

- Four procedures
 - Axillary artery exposure
 - Brachial artery exposure
 - Femoral artery exposure
 - Lower extremity fasciotomy



Methods

- **Phase 1**

- Development of surgical skills assessment method

- **Phase 2**

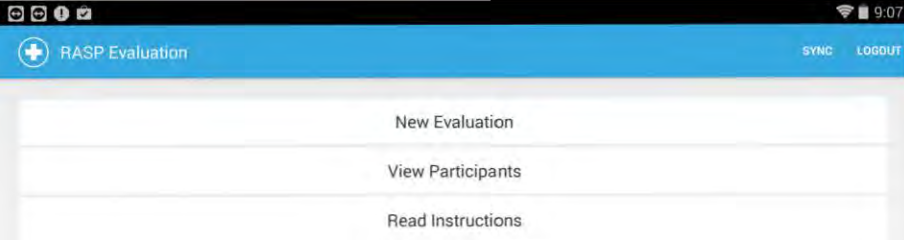
- Assessment of surgical skills before and after training in ASSET course

Methods

- Phase 1: expert assessment
 - 10 experts (trauma fellowship trained, 2-40 years in practice) were interviewed + audio-video-recorded while performing the four procedures
 - “Think out loud”
 - Knowledge questions and answers developed based on expert interview results
 - Consensus conference and video review used to select technical performance metrics

Methods

- Phase 1: novice assessment
 - 10 novice surgeons (non-ASSET trained clinical year 4 to 7 surgical residents and fellows)
 - Performed the same 4 procedures
 - Audio video recorded



Show slides and read the following text



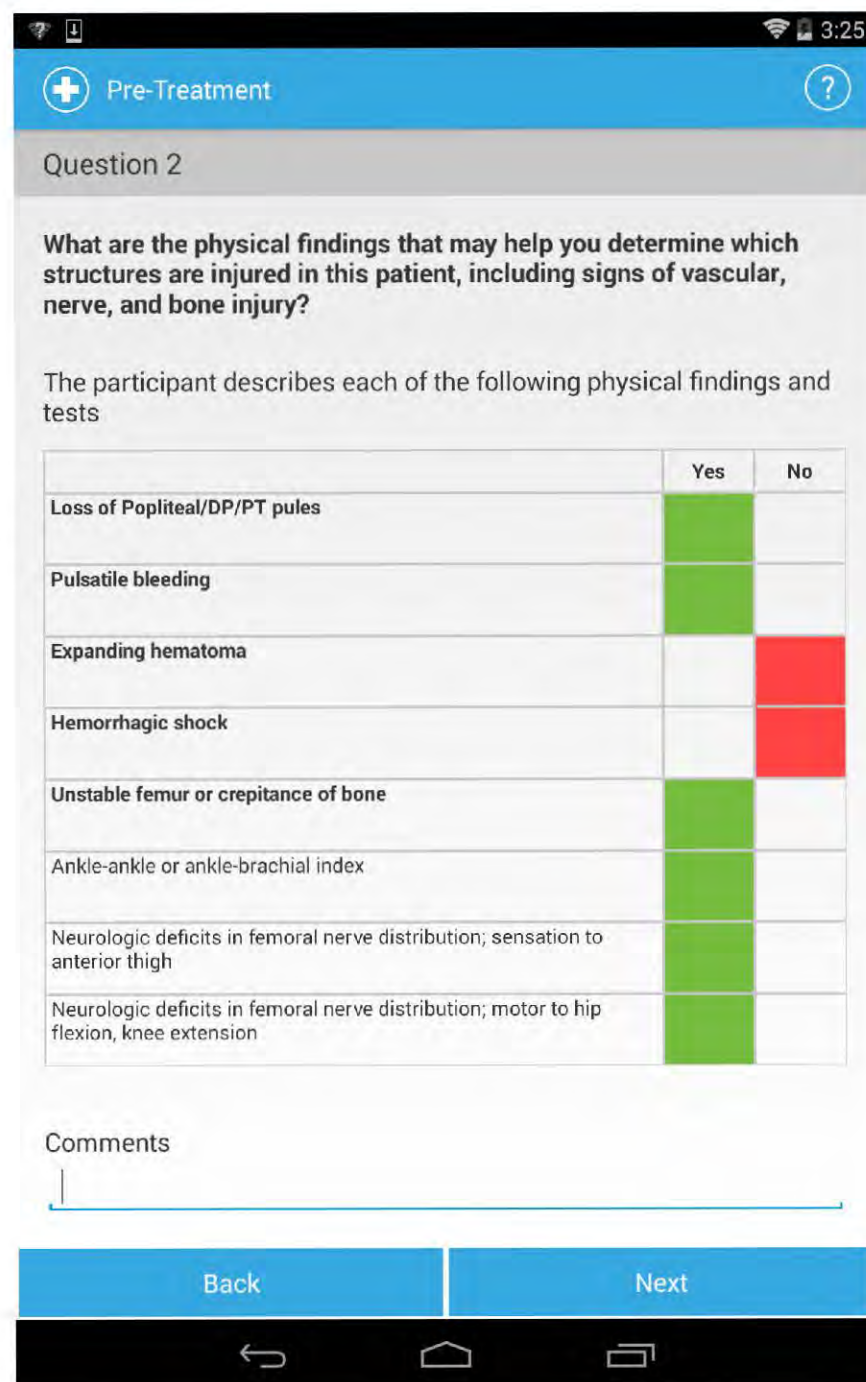
- 24 y/o male who was a victim of a drive by shooting, sustaining a through and through gunshot wound to the Right/Left mid-thigh.

- He was reported to have a large amount of bright red pulsatile blood at the scene.- He was initially taken to a small community hospital without an in-house surgeon where his blood pressure was 80/50 and his heart rate was 140. He was reported to have a markedly swollen thigh with active bleeding and no distal pulses. There are no other injuries.

[Advance slide to show image of wound]

[Advance slide to continue narrative]

- At the outside hospital a tourniquet was placed and he received 3000 cc of crystalloid. He is transferred to your facility now more than four hours after the injury. He received low dose norepinephrine and has a blood pressure of 100/70 and a HR of 130, with a markedly swollen thigh and absent distal pulses.



3:27

Procedure

Question 7

At this time, please verbalize and then mark on the cadaver the landmarks and the incision that you will use on the skin

The participant indicates and marks the following landmarks

	Yes	No
Pubic tubercle	☒	☐
Ant sup iliac spine (ASIS)	☒	☐
Inguinal ligament	☒	☐
Femoral artery (approximate location 1/3 of distance from pubic tubercle to ASIS)	☒	☐
Marks longitudinal incision over femoral artery, 2 finger breadths lateral to the pubic tubercle	☒	☐
Incision extends above inguinal ligament 4-5 cm	☐	☒

Comments

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System update available

Pre-Treatment

The participant describes and performs each of the following steps

Timer 00 min 57 sec	Pause		Reset
	Yes	No	Timed
Knife to skin	☒	☐	00:00
Initial skin incision is adequate to perform exposure	☒	☐	00:05
Correctly identifies Common Femoral Artery	☐	☒	00:44
Correctly identifies Common Femoral Vein	☐	☒	00:07
Correctly identifies Profunda Femoral Branch	☐	☒	00:54
Correctly identifies Superficial Femoral Artery	☐	☐	00:00
Controls Common Femoral Artery with vessel loop	☐	☐	00:00
Controls Profunda Femoral Artery with vessel loop	☐	☐	00:00
Controls Superficial Femoral Artery with vessel loop	☐	☐	00:00
Stop procedure	Stop timer		

Errors

Error: Incorrectly identifies the CFA and does not recognize or correct error	☒
Error: Incorrectly identifies CFA, but is able to recognize	☐
Error: Incorrectly identifies the PFA and does not recognize or correct error	☐

Back
Next

Inter-Rater Reliability Testing

- Randomly sorted video of 10 expert and 10 novices surgeons was scored by 5 trained evaluators
- Intra-class correlation coefficients were calculated for 10 technical skill metrics

Intraclass Correlation Coefficient			
1	Exposes arteries by dissecting directly on anterior surface	Single	0.5
		Average	0.84
2	Manipulates artery by grasping adventitia	Single	0.2
		Average	0.55
3	Uses instruments properly	Single	0.3
		Average	0.68
4	Positions body to use instruments to best advantage	Single	0.41
		Average	0.78
5	Proceeds at an appropriate pace with economy of movement*	Single	0.8
		Average	0.95
6	Handles tissue well with minimal damage	Single	0.36
		Average	0.74
7	Creates an adequate visual field using retractors for procedure*	Single	0.78
		Average	0.95
8	Communicates clearly and consistently*	Single	0.77
		Average	0.94
9	Performs procedure without unnecessary dissection*	Single	0.72
		Average	0.93
10	Continually progresses toward the end goal	Single	0.69
		Average	0.92

Intraclass Correlation Coefficient

1	Exposes arteries by dissecting directly on anterior surface	Single	0.5
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		Average	0.95
8	Communicates clearly and consistently*	Single	0.77
		Average	0.94
9	Performs procedure without unnecessary dissection*	Single	0.72
		Average	0.93
10	Continually progresses toward the end goal	Single	0.69
		Average	0.92

Trauma Readiness Index (TRI)

Points awarded + remaining time allowed
Points available + total time allowed

- Time limit = 20 min per procedure
- Points awarded:
 - Knowledge (Anatomic and Patient management)
 - Procedural steps
 - Technical skills

Phase 1 Novice Surgeons Mean Scores, n=10

	All Four Procedures		Axillary		Brachial		Femoral		Fasciotomy	
	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
Time	16.8	9.4	14.4	14.4	6	20.5	5.3	16.2	8.5	14.4
Knowledge										
• Overall	58	11	50	9	68	11	57	7	56	8
• Anatomic	54	19	58	15	42	20	58	12	58	24
• Management	46	16	37	15	64	12	42	9	42	13
Procedure steps	43	28	48	29	24	28	51	21	49	29
Technical skills	48	10	56	42	53	39	38	39	40	28
Trauma Readiness Index	50	14	49	12	47	18	54	9	52	15

Methods

- Phase 2: Evaluating surgeons before and after ASSET training
- 12 surgical trainees (residents and fellows, clinical year of training 3-7) were assessed before and within 2 weeks after ASSET course
- ASSET course content includes the 4 procedures evaluated in this study among a total of 47 procedures taught during the course.

Phase 2 Surgical Performance Assessment						
	Pre-training		Post-training		Improvement	
	Mean	Std Dev	Mean	Std Dev		p-value
Time (minutes)	13.4	5.9	9.1	4.5	- 4.3	<0.001
Knowledge score						
• Overall	50	13	53	14	+ 3	0.013
• Anatomic	50	16	68	12	+ 18	<0.001
• Management	43	17	45	15	+ 2	0.044
Procedure steps score	46	23	67	16	+ 21	<0.001
Technical skills score	60	18	71	17	+ 12	<0.001
Trauma Readiness Index	50	12	64	10	+ 14	<0.001

Conclusions

- Trauma specific assessment tool
- ASSET training reduced time to vascular control by 1/3rd
- Trauma Readiness Index may be used to show training improvements in various training programs and military pre-deployment courses



Appendix 14: Assessment of surgical anatomy skills in upper and lower limb vascular control before and after training

Podium presentation: Association for Surgical Education (April 2015)

Evan Garofalo, PhD, Stacy Shackelford, MD, Valerie Shalin, PhD, Kristy Pugh, MS, Hegang Chen, PhD, Jason Pasley, DO, Babak Sarani, MD, Sharon Henry, MD, Mark Bowyer, MD, Colin Mackenzie MBChB

Background: Maintaining trauma specific surgical skills is a challenge for military and civilian surgeons. We hypothesize that a trauma training course including rapid upper and lower limb vascular exposure improves correct identification of surgical landmarks, anatomical structures, and shortens time to vascular control. Specifically, improved knowledge of surface landmarks is associated with faster procedures and more successful vessel identification and control.

Methods: We developed a surgical skills evaluation tool through discussion with expert trauma surgeons, video review of 10 experts performing three open vascular exposures (axillary [AA], brachial [BA] and femoral arteries [FA]) on cadavers, and a consensus conference. An Android application was designed to run the tool and two trained evaluators assessed the technical skills of 34 surgical residents (years 3-5) while performing these procedures before and after completing the Advanced Surgical Skills for Exposure in Trauma (ASSET) course. Correct identification of surface anatomical landmarks, incisions, structures in surgical procedural steps, and time to completion of procedure were compared before and after training using Pearson Correlation and Linear Mixed Models test.

Results: Table 1 details results of the analyses. In AA and FA procedures, there is a significant effect of ASSET training showing decreased procedure time ($p < 0.001$), improved surface landmark identification ($p < 0.001$: AA 40%; BA 15%; FA 24%), correct vessel identification and vessel control (AA, FA $p < 0.001$). There was significant correlation between correct surface landmarks, incisions and artery identification with successful vascular control for AA and FA ($r = 0.25$ to 0.44 ; all correlations $p < 0.001$). Decreased procedure time was correlated with correct surface landmarks ($p < 0.02$) and incisions ($p < 0.001$) for the BA procedure. Neither residency year nor evaluator had an effect on the pre and post scores.

Conclusions: Documentation of correct surface landmarks and incisions was associated with swift successful control of upper/lower limb vasculature. By this measure, structural recognition during specific procedural steps and surface anatomic knowledge were highly impactful information taught during a 1-day course. This training approach, normally acquired during the entirety of residency training, may help accelerate acquisition of emergency surgery specific skills to compensate for shortened training hours or when just-in-time training is necessary.

Appendix 15: Mobile Platform for Assessing Emergency Trauma Surgical Skill Performance

Accepted for poster presentation: Association for Surgical Education (April 2015)

Colin Mackenzie, Stacy Shackelford, Evan Garofalo, Hegang Chen, Jason Pasley, Sharon Henry, George Hagegeorge, Kristy Pugh, Mark Bowyer.

Background: Surgical resident's operative trauma experience has decreased from 60-35 cases 1999-2012. A mobile platform would be useful for residency programs to evaluate competence in trauma skills. We tested the hypothesis that remote review of video clips discriminated pre from post training performance in vascular control no differently than co-located performance evaluation.

Methods: Performance of surgical skills were evaluated by two co-located trained experts during three video-recorded vascular exposure procedures (Brachial artery [BA], Axillary Artery [AA] and Femoral Artery [FA]) performed on fresh cadavers by ten 3rd - 5th year surgical residents before and within 2 weeks of Advanced Surgical Skills for Exposure in Trauma (ASSET) training. Metrics included landmarks, specific steps and techniques, expert discriminators and global performance ratings common to 10 experts. The performance metrics were previously validated for BA, AA and FA with inter rater reliability (ICC) analysis showing ICC 0.7- 0.98 among 5 raters. In this study, Pre/Post training video clips of 10 residents for each procedure were randomly ordered for blinded analysis by 2 trained evaluators and compared to same-procedures simultaneously assessed by co-located evaluations. Co-located and video evaluations were compared with Pearson Correlation and Linear Mixed Models.

Results: Evaluation metrics showed no floor or ceiling effects. Expert discriminators (skin incision, logical sequence, anatomic knowledge etc), procedural steps (correct structure identification) and global ratings (1= poor-5=excellent) of anatomy were no different among co-located and video evaluators for BA, AA, FA. Differences in other global ratings of skills, readiness and overall grade (%) were variable between video and co-located evaluations (Table).

Discussion: Remotely situated video review, had agreement in objective pre/post training performance with co-located evaluators, but not in more subjective assessments. Video focused on the surgeon's hands could account for these differences. Video recordings of cadaveric vascular exposure, with remote evaluations of objective metrics assesses residents vascular exposure competence.

		Expert							
		Landmarks (%)	Technical Points (%)	Discrimination (%)	Procedural (%)	Global Anatomy	Global Tech Skill	Global Readiness	Grade (%)
		mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD
Axillary	Pre	86 $\pm$ 6	57 $\pm$ 3	55 $\pm$ 5	38 $\pm$ 5	2 $\pm$ 0.2	3 $\pm$ 0.2	2.2 $\pm$ 0.2	65 $\pm$ 2.3
	Post	46 $\pm$ 6	73 $\pm$ 3.5	75 $\pm$ 5	85 $\pm$ 5	3.5 $\pm$ 0.2	3.5 $\pm$ 0.2	3.7 $\pm$ 0.3	81 $\pm$ 2.4
	Post training Delta	40 ***	16 ***	20 ***	47***	1.4***	1 ***	1.5***	16 ***
	Co-located vs. Video	0.8	0.02*	0.59	0.1	0.09	0.02*	0.3	0.1
	(p value)								
Brachial	Pre	60 $\pm$ 6	62 $\pm$ 3	61 $\pm$ 5	62 $\pm$ 5	2.4 $\pm$ 0.2	2.8 $\pm$ 0.2	2.5 $\pm$ 0.2	69 $\pm$ 3
	Post	66 $\pm$ 6	68 $\pm$ 3	65 $\pm$ 5	79 $\pm$ 6	3.1 $\pm$ 0.2	3.1 $\pm$ 0.2	3.0 $\pm$ 0.2	75 $\pm$ 3
	Post training Delta	7	7	5	18 ***	0.8 ***	0.3	0.5 *	5.5 *
	Co-located vs. Video	0.75	0.02*	0.02*	0.46	0.15	0.27	0.1	0.1
	(p value)								
Femoral	Pre	70 $\pm$ 3.9	56 $\pm$ 3.6	37 $\pm$ 5	44 $\pm$ 6.3	2.5 $\pm$ 0.2	2.4 $\pm$ 0.2	2.2 $\pm$ 0.2	66 $\pm$ 2.3
	Post	85 $\pm$ 3.9	70 $\pm$ 3.6	70 $\pm$ 5	87 $\pm$ 6.3	3.5 $\pm$ 0.2	3.2 $\pm$ 0.2	3.4 $\pm$ 0.2	79 $\pm$ 2.3
	Post training Delta	14 *	14 ***	33 ***	44.5 ***	1 ***	0.9 ***	1.2 ***	13 ***
	Co-located vs. Video	0.004 ***	0.04 *	0.5	0.7	0.2	0.07	0.04 *	0.004 ***
	(p value)								

$\alpha=0.05$. Significance is demarcated as: *** $p < 0.0001$; ** $p < 0.001$; * $p < 0.05$

Table: Shows mean $\pm$ standard deviation (SD) of metrics across top X axis. Along the Y axis are shown Axillary, Brachial and Femoral artery vascular exposure and control procedures performed by 10 surgical residents with the Pre Post training differences and whether the evaluators used video or were co-located. Expert, and Procedural evaluations and Anatomy Global Ratings were not different between video and co-located evaluators.

Appendix 16: Surface anatomy in the performance of a lower extremity fasciotomy before and after training

Accepted for poster presentation: Federated American Societies for Experimental Biology, American Association of Anatomists (FASEB, AAA March 2015)

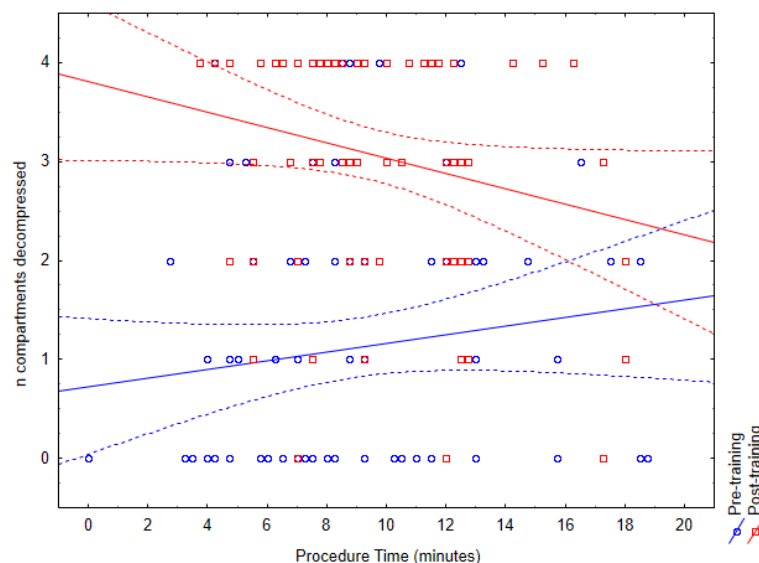
Evan Garofalo, Stacy Shackelford, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie

With shorter training hours, acquiring trauma surgical skills on-the-job is challenging for civilian and military surgeons. We hypothesize that a training course including lower extremity (LE) fasciotomy will improve knowledge of surgical landmarks, anatomical structures, and procedure time. Specifically, improved knowledge of surface landmarks will correlate with faster and successful 4 compartment decompression.

Surgical residents (n=34) were tested with validated metrics performing a 2 incision 4 compartment fasciotomy on a cadaver before and after the Advanced Surgical Skills for Exposure in Trauma (ASSET) course. Surface landmarks, incision placement, surgical procedural steps, and procedure time were compared before and after training with Linear Mixed Models and Pearson Correlation.

After training, residents improved in landmark identification (+33%), incision placement (+34%), and successful 4 compartment decompression (all $p<0.001$). More compartments were completely opened in less time (ANCOVA $p<0.05$; figure). Correct landmarks and incisions correlated with successful decompression ($r=0.42-0.5$; $p<0.001$).

Improved surface anatomic knowledge increased successful fasciotomy. This knowledge is normally acquired on the job during residency but specific training may help accelerate the acquisition of fasciotomy skills to compensate for reduced training hours.



DEFENSE HEALTH AGENCY - JOINT PROGRAM COMMITTEE – 1 (JPC-1)

In Progress Review (IPR) August 2014 (Orlando, FL)

“USE OF PERFORMANCE MEASURES TO EVALUATE, DOCUMENT COMPETENCE AND DETERIORATION OF ASSET SURGICAL SKILLS – MPI-PSD” – Univ. of Maryland;

PI: Dr. Colin Mackenzie

1) Strength(s) of Scientific Methodology / Approach	2) Strength(s) of Investigative Team's Risk Identification / Risk Management Approach	3) Strength(s) of Investigative Team's Schedule / Performance - Goals, tasks, milestones, and deliverables	4) Strength(s) of Results / Deliverables / Outcomes Regarding respective (a) needs of Military / End User and (b) project's goals, tasks, milestones, and deliverables	5) Recommendation, based on how well it addresses needs of the DOD or any individual agency (e.g., Army, Air Force, Navy, Marines) based on capability being developed. Identify any Military Organization, Individual Subject Matter Expert, End-User, &/or Advanced Developer who may be able to accelerate transition.	6) Overall Global Score
Score: 3 - Good Hypothesis: 1. Metrics can be used to document surgical competence. 2. The metrics can document decay of skills after five years.	Score: 3 - Good RISK: Q1. Getting enough ASSET alumni to take the ASSET course. 1. Develop performance metrics for surgeons and their skills degradation using the ASSET course. DONE 2. Four injuries: femoral artery injury, auxiliary artery, compartment syndrome, and fasciotomy.	Score: 3 - Good 1. Develop performance metrics for surgeons and their skills degradation using the ASSET course. DONE 2. Four injuries: femoral artery injury, auxiliary artery, compartment syndrome, and fasciotomy.	Score: 3 - Good Doing before and after checklist on video recordings on residents and staff doing the ASSET course. Developed a new metric (RTI) to score the procedures.	Met essential needs	Score: 3 - Good
Score: 4 - Outstanding Well stated problem to be addressed skill decay of trauma surgical skills vascular injuries. Sound methodological approach.	Score: 3 - Good cohort of 500 surgeons data collection after period of non-use	Score: 3 - Good seems to be on schedule	Score: 4 - Outstanding excellent study has the potential to contribute significantly to patient safety.	Met essential needs Significant study results will positive impact combat surgery.	Score: 3 - Good Excellent study recommend continue funding.
Score: 3 - Good	Score: 3 - Good	Score: 3 - Good	Score: 3 - Good Seems like JPC/DoD is creating several automated	Met essential needs	Score: 3 - Good

			evaluation tools. Would probably be a better approach to have one system with banks of questions for different skills that could be accessed/modified by all.		
Score: 3 - Good	Score: 3 - Good	Score: 3 - Good	Score: 3 - Good	Met essential needs	Score: 3 - Good
Score: 4 - Outstanding Solid methodology. I believe the strength lies in validating a specific solution to the combat skill decay.	Score: 4 - Outstanding Good disclosure of all risks.	Score: 2 - Poor The team appears is over budget and appears at risk of falling behind schedule. I believe that the validation metrics might be difficult to implement.	Score: 3 - Good The deliverables could be very valuable.	Exceeded expectations Could be very applicable to DoD very quickly	Score: 3 - Good Need to share lessons learned with other entities who are submitting proposal. I suggest the JPC-1 come up with some "reading lists" based on different announcements.
Score: 3 - Good	Score: 3 - Good	Score: 3 - Good	Score: 4 - Outstanding	Met essential needs	Score: 3 - Good Military focused effort with sound methodology to establish best practice measures to complete defined skills for the 4 ASSET skills. Sound methodology with preliminary results demonstrating sound IRR on measures. Approach and method provides a good framework for enhancing training on these military critical skills.
Score: 3 - Good Small sample size.	Score: 3 - Good	Score: 3 - Good	Score: 3 - Good	Met essential needs	Score: 3 - Good
Score: 3 - Good	Score: 3 - Good	Score: 4 - Outstanding	Score: 4 - Outstanding Additional findings regarding cadaver tissue versus modeling beneficial.	Exceeded expectations	Score: 3 - Good

USE OF PERFORMANCE MEASURES TO EVALUATE, DOCUMENT COMPETENCE AND DETERIORATION OF ASSET SURGICAL SKILLS – MPI-PSD

Dr. MacKenzie presented this project. He cited statistics on the high number of battlefield deaths that could be prevented if bleeding could be better controlled.

Question: how do they define the novices? **Dr. MacKenzie** said they are second- and third-year residents who have never before been trained in ASSET.

Question: Are any of the differences statistically significant? **Dr. MacKenzie** said they will have to finish the analyses to be sure, but he does not think they are.

Question: What happens during the non-use period? Surgeons will continue to do the kinds of things they do, not necessarily trauma surgery but perhaps having some of those components. He asked if they have looked at what those in their sample have been doing during that period. **Dr. MacKenzie** agreed that this is important. They are looking at surgeons' logs to see what they have been doing.

Question: Will they will be able to get enough ASSET alumni to come back for the reassessment. **Dr. MacKenzie** said they are offering substantial incentives to get people to come back for a morning's worth of work. Also, these people tend to be loyal to the person who developed the ASSET training, and are willing to participate in this assessment effort.

Question: Are additional comments are being collected on the gaps between the simulation system models and the cadaver, especially from the expert cohort side? **Dr. MacKenzie** said they will have a lot of information in addition to what was presented here.

Question: Have they have thought about what the refresher model would look like for the skills that have decayed. **Dr. MacKenzie** said that this is why using the head-mounted camera is so important. It will help to identify exactly what steps they are missing, and which skills have decayed.

GOVERNMENT REVIEW OF PRESENTATIONS

Comment: It was good that there was a specific course, with validation of that specific course to teach a skill.

Comment: the self-assessments are not very reliable. What the researcher is doing is very well done. He wants to know more about what the physicians are doing during the periods of non-use, and if skill decay is really being measured.

Comment: This is a very time-intensive evaluation process. Once it is validated, the implementation will be complicated. He is not convinced they will be able to implement this methodology. **Comment:** this kind of study often starts with a set of skills, but some drop out as the researcher learns that some are more

predictive than others. **Comment (original panel member):** specifically the video assessment is the time-intensive part. **Comment:** PI even did not know how that could be sped up. **Comment:** agreed that it is very labor-intensive. However, **Comment:** the video assessment is being done for research purposes, and the researcher is hoping to get a decay curve that can be used in the future. This final statement helped conclude the discussion on this evaluation process point.



Use of Performance Measures to Evaluate, Document Competence and Deterioration of Advanced Surgical Skills Exposures for Trauma (ASSET) Course Surgical Technical Skills

Colin F Mackenzie MD -
Principal Investigator

Col Stacy Shackelford MD FACS,
Col (R)Mark Bowyer MD FACS,
Sharon Henry MD FACS. Co-
Investigators





Additional Project Information



Lab/Company/Group: University of Maryland

Principal Investigator: Dr. Colin Mackenzie

Government GOR / COR: Mr. Tony Story

Government Project Officer: Ms. Heran Gebreyesus

Contract Instrument: Cooperative Agreement

Period of Performance: 15 Feb 2013 – 14 Feb 2016

Contract Specialist: Ms Elena Howell(Bane)

EDMS # : 5652

Award #: W81XWH-132-0028



Team / Roles & Responsibilities



Retention and Assessment of Surgical Performance

(RASP) Team: Colin Mackenzie (Chair), COL Stacy Shackelford FACS, COL (Rtd) Mark Bowyer FACS, Sharon Henry FACS, Evan Garafalo PhD

Valerie Shalin PhD (Psychologist/Human Factors).

Evaluators: TEAM + Jason Pasley FACS, Babak Sarani FACS, Mayur Narayan FACS, Elliot Jessie FACS, Amechi Anazodo MD, Brandon Bonds MD

Script Readers: Megan Holmes, Kristy Pugh + Nicole Squires



PROBLEM: TRAINING & SKILL RETENTION GAP



- Fewer graduating residents document experience with vascular trauma. [1,2]
- Major vascular repairs for trauma by graduating chief residents (ABS data) decreased on average from 5.0 in 2001-2002 to 2.1 in 2010-2011 over the course of a residency in general surgery [3]
- The average number of fasciotomies reported was 1.2; exposures of the brachial artery by chief residents in 2010-2011 was 0.0.
- Inexperience with LE fasciotomy has contributed to loss of life and limb due to incomplete or delayed fasciotomies.[4]
- Duration of Surgical Skills Retention and identification of need for re-training remain unknown
- Objective measures of acquisition & retention combat specific surgical skills are required

[1] *J Trauma*. 2003;54(1):161-3

[2] *Mil Med*. 1989; 154(11):581,

[3] http://www.acgme.org/residentdatacollection/documantation/statistical_reports.asp

[4] *J Trauma*. 2008; 64 (2 suppl) S153-162



SOLUTION: Performance metrics on FOUR ASSET Surgical Procedures Before and After Training



- Femoral artery injuries prevalent in Lower Extremity [LE] [1];
- Upper Extremity: Axillary artery (23%), Brachial artery (58%) [2].
- Extremity wounds in combat casualties develop compartment syndrome; fasciotomy, esp. of LE, is frequently required. [3]

[1] *J Vasc Surg.* 2008; 47(6): 1259-64,

[2] *Ann Vasc Surg.* 2006; 20(4): 429-34,

[3] *J Trauma.* 2008; 64 (2 suppl) S153-162



HYPOTHESIS:



Validated surgeon performance measures will demonstrate the effectiveness of ASSET training, document surgical competence, detect skill deterioration in combat-relevant surgical skills and provide critical insight into the duration and degradation of those skills over time periods of 1- 5 years.



Military Relevance

- **Bleeding is the leading cause of early preventable death in military & civilian casualties.**
- **Difficult for military trauma surgeons to maintain proficiency in exposure and vascular control of major blood vessels**
- Vascular injury in modern combat is five times that reported in previous wars [1].
- 50-70% of all injuries treated during Operation Iraqi Freedom are extremity vascular injuries [2].
- Exsanguination from upper and lower extremity wounds is a leading cause of preventable death on the modern battlefield [3].
- *[1] Ann Surg. 2011; 253(6): 1184-9*
- *[2]. J Trauma. 2006: 432-42*
- *[3] J Vasc Surg. 2008; 47(6): 1259-64*



Timeline and Phases of Study

Phase 1	Year One												Year Two												Year Three																											
Month of study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																
Task A	SME Cognitive Work and Task Analysis Model Construct Validity, Validate & Modify TRR n= 10 Experts & 10 Novices																																																			
Phase 2 –Untrained Subjects – test base line skills, take ASSET course, test post course, reevaluate at either 12 or 18 months (n=40)																																																				
Task B-1 (subjects 1-10)																																																				
Task B-2 (Subjects 11-20)																																																				
Task B-3 (subjects 21-30)																																																				
Task B-4 (Subjects 31-40)																																																				
Phase 3 – bring back previously trained ASSET surgeons and retest (n= 40)																																																				
Subjects return at intervals from 2-5 years after initial ASSET course													Subjects asked to return and perform ASSET skills with scheduling to coincide with intervals of 2-5 years from original course																																							



RASP Project Description & Tasks Phase 1- 3



Phase 1 – Develop and Validate surgical performance measures

- Analysis of surgical self assessments in 523 surgeons completing ASSET Course over past 5 years
- Develop technical and non-technical skills performance metrics
- Mobile software to evaluate competency in technical and non-technical skills
- Validate Performance Metrics with Inter-Rater Reliability in Preliminary studies



Phase 2 – Testing the impact and retention of skills comparing physical model fidelity and unpreserved cadavers in skills training

- Compare surgical performance Novices v Experts using Performance Metrics
- Demonstrate Evaluation of Objective and Subjective instructor assessments
- Test performance metrics pre and post training and compare with self assessments
- Compare efficacy of training between cadavers v physical models
- Define time frames for deterioration of surgical skills



Phase 3 – Compare performance evaluation metrics with self and performance evaluation assessment 1-5 years after taking ASSET Course

- Compare self assessment of surgical skills with an objective assessment incl. Technical & Non-Technical skills



Outcome

Modified surgical skills program with demonstrable surgical skills performance and retention





METHODS – Phase 1



- **Video Record** 10 Experts “Talk Aloud” during 4 ASSET procedures.
- Video Record 10 Non-ASSET Trained novices
- **Consensus Conference** among experts: identify essential expertise , common errors and correct technical Skills = **Evaluation Metrics**.
- **Develop Standard Script: Train Evaluators:**
Incorporate Script and Evaluation Metrics into **Mobile Tablet** for ‘real-time’ evaluations and data collection. **Validate:** Using blinded video review



Using only small portion of incision space and “Keyhole” Surgery





Inappropriate incision: Lack of Femoral Art. anatomy knowledge. Incorrect knife holding





Inadequate length Medial FAS incision





Project Description Phase 2 and 3



- **Phase 2: Apply Performance Evaluation Metrics**
- **ASSET Train 40 surgeons:** use video recording and co-located evaluation to compare surgical performance before and after training.
- *Perform 4 ASSET procedures in random sequence on physical model and cadaver*
- **Reevaluate** surgeons at either 12 (n=20) or 18 months (n=20) on physical model & cadaver
- **Phase 3: Examine technical skills degradation over 2-5 years among 40 surgeons participating in past ASSET courses.**
- **Evaluate** previously ASSET-trained surgeons on cadaver and physical model at intervals of 2-5 years from original training.
- Complete skills assessments as originally administered
- Data analyses; *draft paper and present results.* Final report



47 ASSET Course Procedures :



Pre/Post Confidence n = 523 surgeons

- Lowest Pre ASSET self-reported confidence in Chest 32%, highest in Abdo/pelvis 52%
- Post ASSET 39 % showed increase and 39% retained high confidence, 20% low confidence
- Chest > upper limb > lower limb,>neck > abdo pelvis. Chest 51% surgeons from low to high.
- All surgeons improved ($p < 0.0001$) confidence in all 5 anatomic regions. High confidence in 78% of 47 procedures
- Most improved :Upper limb 49% improved low to high ($p = 0.017$).
- Lowest improvement in Axillary artery exposure.
- Confidence improvement varied by specialties and experience levels, confidence levels improved most for residents ($n = 244$)
- Limitation: Need Objective surgical skill performance metrics



Trauma Readiness Index (TRI) Metric



- Video 10 experts (E) and 10 novice (N): 4 RASP procedure(AA, BA, FA, FAS) in fresh cadavers
- 10 surgical steps, 6 operative maneuvers common to experts & 5 performance global ratings
- 8 knowledge Q's: knowledge of injuries, indications, complications, common errors
- Evaluations by trained video reviewers (n=5) blinded to E or N clips compared by item analysis.
- Descriptive regression modeling. Intra-class correlation coefficient (ICC) for Inter-Rater Reliability



Validation of Metrics:

Inter- Rater (ICC) Reliability of Technical Performance Metric (TRI) by 5 Raters

	Intraclass Correlation Coefficient (ICC)			
	Axillary artery exposure	Brachial artery exposure	Femoral artery exposure	Fasciotomy
Technical Skill				
Obtains necessary exposure	0.98	0.92	0.79	0.97
No unnecessary dissection	0.96	0.91	0.96	0.94
Proceeds at appropriate pace	0.97	0.88	0.94	0.97
Performs with logical sequence	0.93	0.87	0.97	0.95



Results of Preliminary TRI testing



- Among 10 N: No Floor/Ceiling effects of TRI
- Of 16 technical skills found in E, in N =51-59%
- Global overall performance rating = 54%
- Global Technical Performance = 69%
- ICC ranged from 0.79 – 0.99 depending on procedure among AA, BA, FA, FAS
- **Conclusion:** *TRI Evaluation metrics discriminated N from E with excellent Inter Rater Reliability.*
- *Validation in a larger population Before/After skill training is needed*



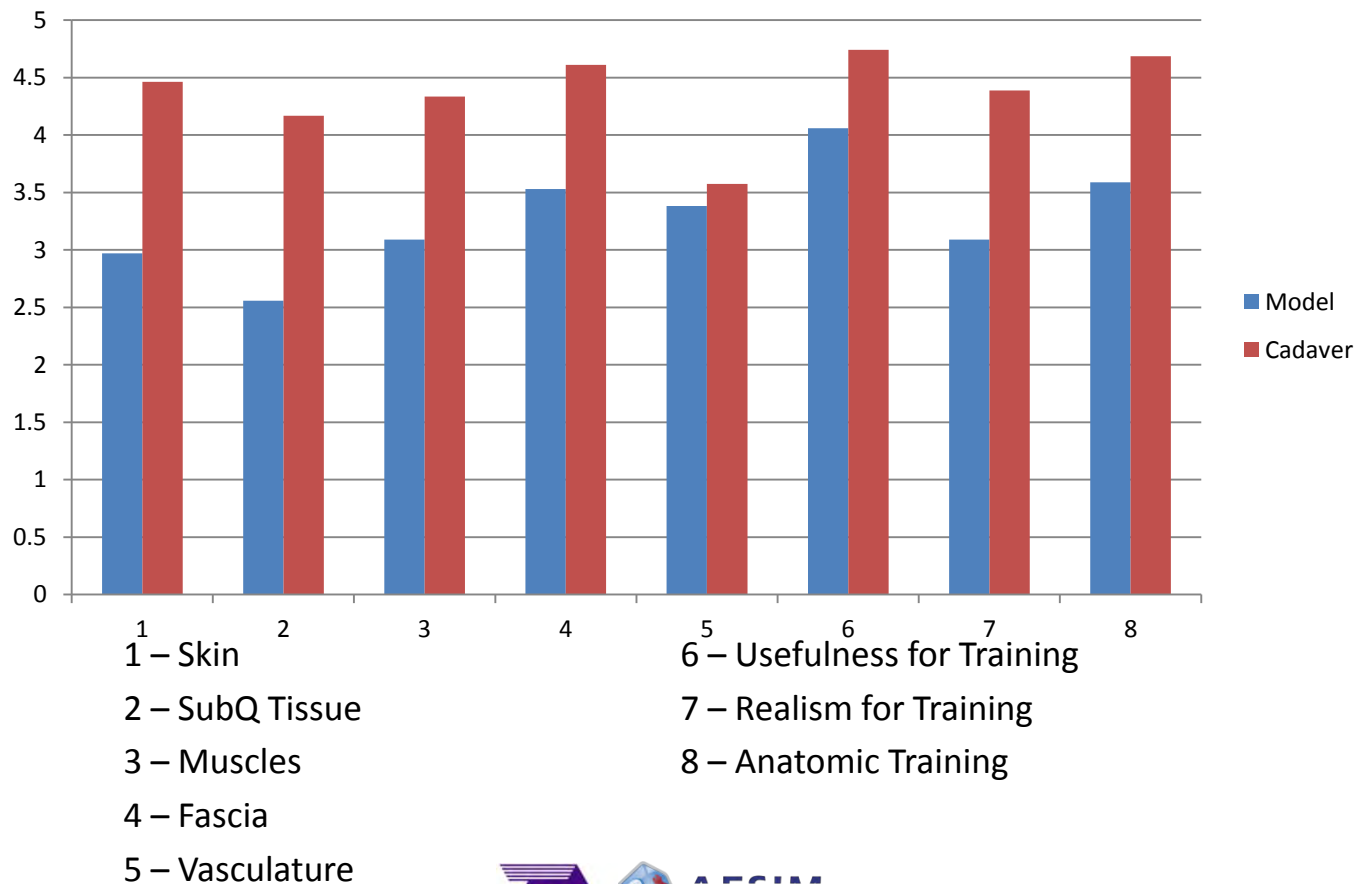
TRI Testing Before/After ASSET training n = 12



- TRI for 3 vascular exposures and FAS improved 14% after training.
- Procedural steps skills TRI increased 21%
- Surgical Technical Skills increased 12%
- Overall knowledge improved 3%
- Anatomic knowledge improved 18%
- Management knowledge improved 2%
- Time to completion decreased 4.3 min (13.4- 9.1)
- N= 40 surgeons now enrolled..analysis on-going



Fidelity of physical models vs cadaver N= 40 responses . Likert 1-5 Scale





Funding Status

	<u>Budget</u>	<u>Expended Funds</u>	<u>%</u>
Year 1	\$944,593	\$709,436.14	75.10%
Year 2	\$553,869	\$416,283.25	75.16%
YEAR 2 OPEN ENCUMBRANCES ARE \$266,095.03			



Challenges

- Hiring qualified Research Assistants with Human Anatomy experience
- Scheduling trained Evaluators
- Scheduling last-minute surgeon drop-outs
- Realistic Physical Model production & delivery
- Camera system with unobstructed view
- Time and reviewers needed for video review
- RASP App modifications



Risks & Risk Mitigation Strategies / Metrics



Hired part –time Research Assistants for PhD
program Anatomy Dept. JHU

Evaluators Trained by Teleconf, video and Handbook

Waiting List started: Fill-in for Drop-outs

Delivery and production worked out with
manufacturer.

Dividing video review among several reviewers

RASP App revisions sorted out after week long visit
with developer



Regulatory Items

IRB at University of Maryland and DoD was negotiated expeditiously...THANK YOU

Budget Modification submitted June 2013 to meet unexpected contingencies.

Total \$\$ unchanged SOW unchanged



Intellectual Property & Publication Plan



- Potential IP includes 1) RASP mobile App for surgical performance evaluation; 2) Head-camera and evaluation system with Physical Models as a Mobile Surgical evaluation Platform; 3) Trauma Readiness Index (TRI) Metric.
- Publication Plan:
 - a) Assessing surgical simulation: A utility analysis of ASSET Course *In Progress*;
 - b) Literature Review of Surgical Performance Metrics Development;
 - c) Methods used for surgeon performance metrics: gaps in current assessments;
 - d) Data analyses of technical and non –technical skills before and after ASSET training





ABSTRACTS ACCEPTED/Presented



- 1) **EVALUATION OF INDIVIDUAL SURGEON TECHNICAL SKILLS DURING FOUR EMERGENCY PROCEDURES**
Colin F Mackenzie, Evan Garofalo, Hegang Chen, Valerie Shalin, Kristy Pugh, Stacy Shackelford, Sharon Henry, Mark Bowyer, Mark Fitzgerald, Joost Funke Kupper, George Hagegeorge, Peter Hu, Kon Mouzakis. **Accepted for Podium Presentation Association of Military Surgeons of US (AMSUS)**
- 2) **ASSESSING SURGICAL SIMULATION: A UTILITY ANALYSIS OF THE ADVANCED SURGICAL SKILLS FOR EXPOSURE IN TRAUMA(ASSET) COURSE**
Stacy Shackelford, Evan Garafalo,,Megan Holmes, Konstantinos Kalpakis, Sharon Henry, Colin Mackenzie , Mark Bowyer. **Accepted for Podium Presentation American College of Surgeons Oct 2014**
- 3) **MOBILE PLATFORM TO EVALUATE INDIVIDUAL TECHNICAL SKILLS**
Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kupper, George Hagegeorge, Peter Hu, Evan Garofalo, Mary Njoku, Stacy Shackelford. **Accepted for Presentation: American Society of Anesthesiologists (ASA)**
- 4) **DEVELOPMENT OF A TRAUMA READINESS METRIC SCORE FOR SURGEONS**
Evan Garofalo, Stacy Shackelford, Valerie Shalin, Megan Holmes, Jason Pasley, Elliot Jessie, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie. **Accepted for Podium PRESENTATION: Military Health Services Research Symposium (MHSRS)**
- 5) **MOBIE PLATFORM TO EVALUATE INDIVIDUAL SURGEON TECHNICAL SKILLS**
Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kuppe r, George Hagegeorge, Peter Hu, Evan Garofalo, Mark Bowyer, Sharon Henry, Stacy Shackelford. Shock Trauma Anesthesiology Research, USAF C-STARS Baltimore, USUHS Bethesda USA, The Alfred Hospital and Swinburne University, Melbourne, Australia
- 6) **THE ASSETS OF ASSET: IMPROVING SURGICAL PERFROMANCE CONFIDENCE THROUGH AN ANATOMY AND SKILLS REVIEW COURSE FOR SURGEONS**
Evan M Garofalo, Stacy Shackelford, Megan A Holmes, Colin Mackenzie, Mark W Bowyer. **Poster Presentation: at Federation of American Societies for Experimental Biology (FASEB)**



Presentations and other ABSTRACTS



- **1) House Armed Services Committee and JCP-1 Leadership , Congressional Staffers visited RASP Laboratories July 16th during use of Cadavers and A Demonstration of Hyper-Realistic physical Model**
- **Abstract Submitted: ACCURATE ASSESSMENT OF SURGICAL SKILL IMPROVEMENTS AFTER TRAINING . ,Stacy Shackelford, Evan Garofalo, , Valerie Shalin, Kristy Pugh,, Jason Pasley,, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie . *Submitted to: Eastern Association of Surgery for Trauma (EAST)***



Transition / Business / Marketing Plan

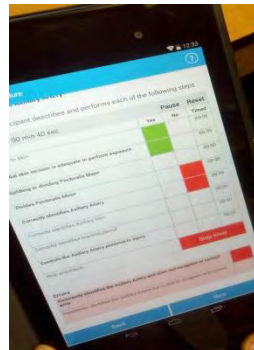


Transition: New Funding Application.

Business:

RASP App on Tablet

Head Camera and Hyper-Realistic Model Systems:
Allows Mobile evaluation platform with **Trauma Readiness Index Metric**





Next Steps

- New Funding application:
- **Methods:** Using the Validated and Tested RASP Metrics Compare Mental Rehearsal v Heads-Up display on surgeon's technical performance during 4 ASSET vascular control procedures.
- **Hypothesis:** Heads-Up Displays or Mental Rehearsal can replace Cadaver training for the 4 ASSET vascular control procedures



So What? (Summary / Conclusions)



- Lack of currency in trauma surgery skills has been identified as a significant barrier to military medical readiness for surgeons.
- No clear standards/ data currently exist on factors affecting critical combat-relevant surgical skills
- The RASP App and the physical model system that will emerge from these studies will be readily deployable as a means of evaluating surgeon readiness to perform emergency vascular control procedures

many specialties, deploying military surgeons and surgery residents.

We compared self-reported confidence of participants (n=562) in surgical tasks (n=47) at baseline and directly after ASSET training to examine the effect of the course stratified by surgical experience level (resident/fellow; <8 years post-residency; 8+ years post-residency), specialty (trauma/vascular; general surgery; other specialties), and body region.

Results of Freeman-Halton 3x2 tests indicated significant gains in confidence scores for all specialties ($p<0.02$), particularly for general surgeons ($p<0.01$) and exposures in the chest ($p<0.001$), after ASSET. There was no difference in confidence gained by surgical experience. This study demonstrates the value of continuing education in applied anatomy for clinical practice. Given the frequency of vascular trauma in current military conflicts, the impact of ASSET is particularly relevant for preparing deploying surgeons for the theatre.

Results

Figures 1 & 2 report the average number of select procedures reportedly performed. Pre- confidence levels generally align with number of procedures reportedly performed by specialty and experience level.

Tables 2 & 3 detail the median Pre- & Post-ASSET confidence scores by experience and specialty. Confidence increased significantly for all Pre-Post pairs at $\alpha=0.05$

Of low Pre-ASSET confidence:

- 39% high Post confidence for all procedures.
- 49% high Post confidence for upper limb procedures

Experience: Significant effect of experience on Post-ASSET confidence, for all body regions but lower limb (Table 5). Residents report low to high confidence shifts most, particularly for lower limb and pelvis. Senior Attendings (>8 years practice) report low confidence Pre & Post training.

Specialty: Significant effect of specialty on Post-ASSET confidence, for all regions but lower limb (Table 6). Most improved confidence: General Surgery (B)
Least improved body region: chest, abdomen & pelvis

Discussion / Conclusion:

Analyses show that all specialties and experience levels derived benefit from ASSET by improving overall confidence levels with vascular exposures. Confidence improved most for procedures in the upper limb. Residents/fellows and General surgeons achieved the greatest improvement in confidence levels, particularly in body regions seen the least often clinically. This method of study has limitations, relying on memory recall and subjective confidence metrics. Studies are underway to develop objective metrics to assess surgical skills.

Major vascular procedures: 8 to 0.7

The Advanced Surgical Skills for Exposure in Trauma (ASSET) course was developed to address declining residency training experience:

- Launched in 2010 and approved by American College of Surgeons
- 1 day cadaver-based course reviews anatomy and surgical skills to perform all major vascular exposures, emphasizing swift exposure as vital for control of major hemorrhage.
- Part of military pre-deployment training and surgical residency programs to review trauma surgical skills.

Research question: *Is there an effect of the level of surgical experience or surgical specialty on confidence to perform procedures independently after ASSET training?*
We hypothesize that general surgeons (B Specialty) and Resident / Fellows will report the greatest improvement in confidence.

Figure 1: Average number of procedures performed by specialty group

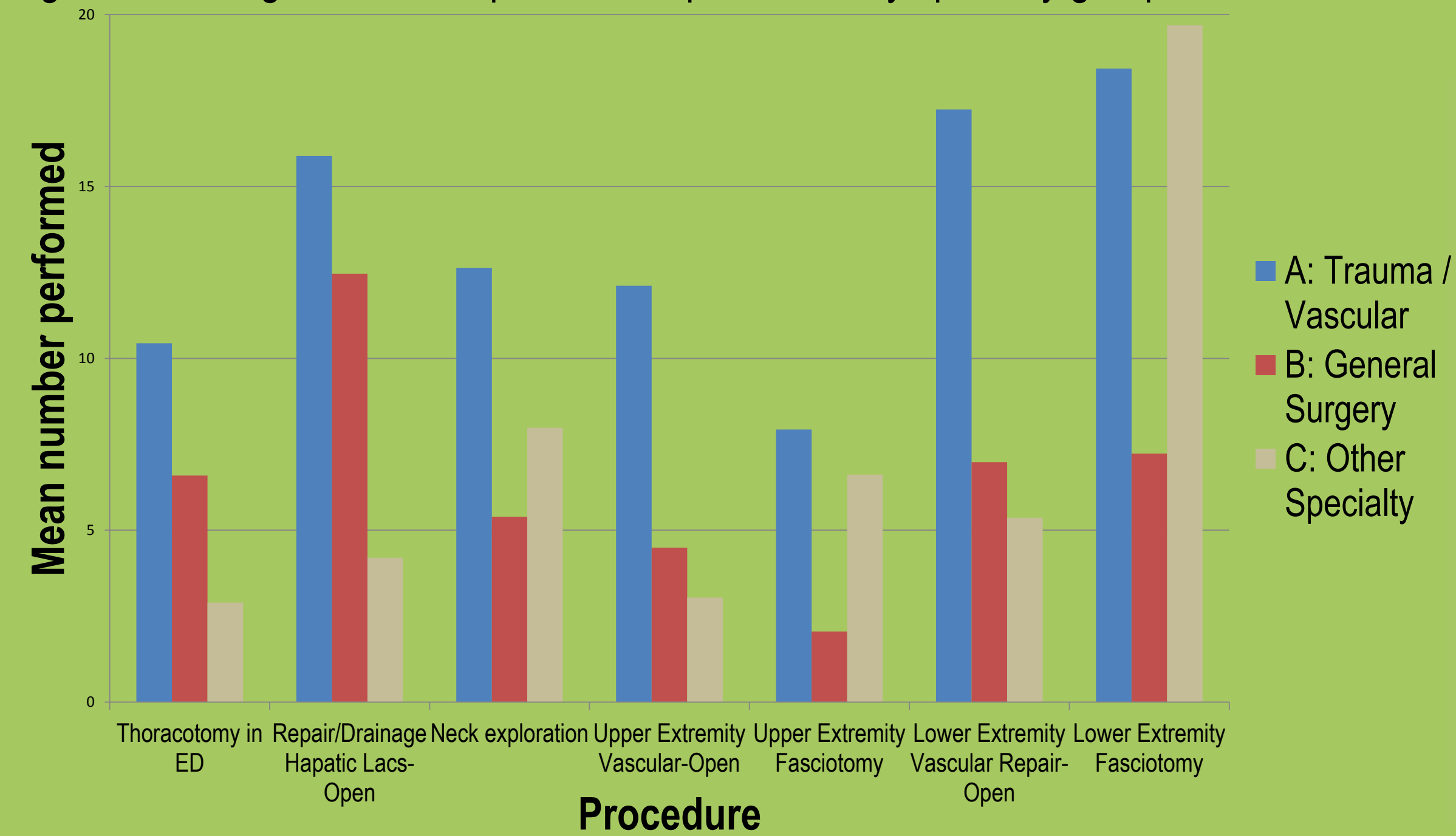


Figure 2: Average number of procedures performed by experience level

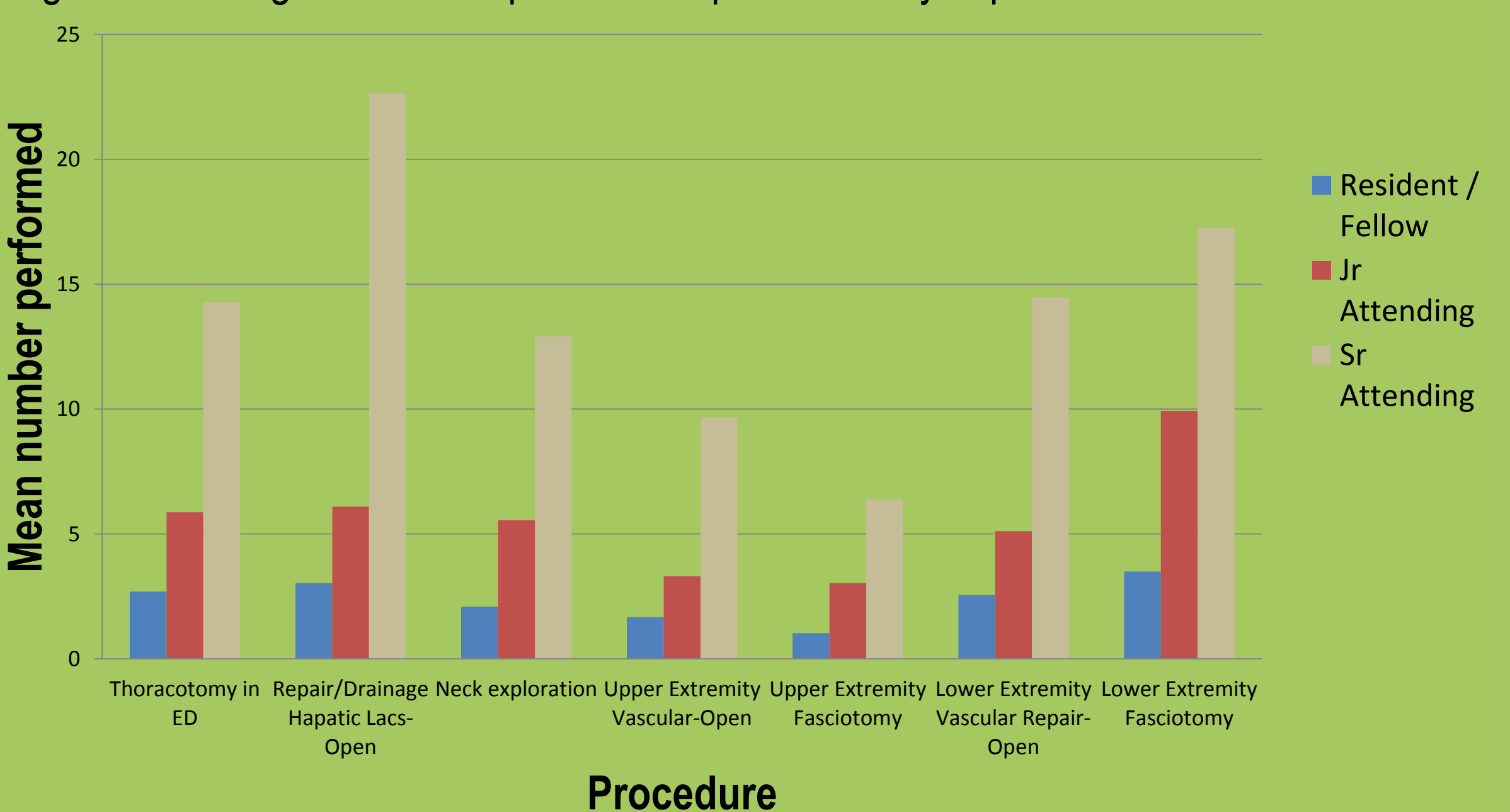


Table 2: Summary of median Pre- and Post-ASSET confidence scores for body region by experience level. (all pair comparisons are significant at $p<0.05$ - Wilcoxon matched pairs)

		All Regions	Upper Limb	Lower Limb	Neck	Chest	Pelvis & Abdomen
Resident	Pre	3	3	3	3	2	3
	Post	4	4	4	4	4	4
Jr Attending	Pre	3	3	4	4	3	4
	Post	4	4	5	4	4	5
Sr Attending	Pre	4	3	4	4	3	4
	Post	5	5	5	5	4	5

Table 3: Summary of median Pre- and Post-ASSET confidence scores for body region by Specialty. (all pair comparisons are significant at $p<0.05$ - Wilcoxon matched pairs)

		All Regions	Upper Limb	Lower Limb	Neck	Chest	Pelvis & Abdomen
A Specialty	Pre	4	4	5	4	4	5
	Post	5	5	5	5	5	5
B Specialty	Pre	3	3	3	4	3	4
	Post	4	4	4	4	4	5
C Specialty	Pre	2	3	3	2	1	1
	Post	4	5	4	4	3	3

Table 4: Direction of change in self-reported confidence (% of all 523 surgeons) after ASSET training by body region Low confidence is defined as Likert 1 to 3, high confidence Likert 4 to 5. Results are given Freeman-Halton 1x3 contingency testing comparisons of directional change among all surgeons undergoing training.

		All Regions	Upper Limb	Lower Limb	Neck	Chest	Pelvis & Abdomen
All Surgeons	Low to High	39	49	40	39	45	32
	Stayed Low	20	17	22	20	24	18
	Stayed High	39	33	37	40	30	48
Freeman-Halton p		0.025*	<0.0001*	0.06	0.021*	0.017*	0.001

Acknowledgements / References:

Thank you to the ongoing effort of American College of Surgeons and local programs who continue to enroll in the program. Funding support from:
1) Wilkey RN. Federal Whistleblower Protection: a means to enforcing maximum-hour Graduate Medical Education. General Surgery: National Program Statistics Report on trauma: a new surgical skills cadaver source for surgery residents and fellows. J Trauma for exposure in trauma (ASSET): the first 25 courses. J Surg Res 2013;183:553-558

Appendix 19: Current list of works

Abstracts for presentation

1. **The assets of ASSET: Improving surgical performance confidence through anatomy and skills review course for surgeons** (Poster: Federation of American Societies for Experimental Biology (April 2014)
Authors: Evan Garofalo, Stacy Shackelford, Megan Holmes, Colin Mackenzie, Mark Bowyer
2. **Development of a Trauma Readiness Metric Score for Surgeons** (Podium: Military Health Services Research Symposium (MHSRS, August 2014)
Authors: Evan Garofalo, Stacy Shackelford, Valerie Shalin, Megan Holmes, Jason Pasley, Elliot Jessie, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie
3. **Mobile Platform to Evaluate Individual Surgeon Technical Skills** (Poster: Military Health Services Research Symposium MHSRS, August 2014)
Authors: Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kupper, George Hagegeorge, Peter Hu, Evan Garofalo, Mark Bowyer, Sharon Henry, Stacy Shackelford
4. **Mobile Platform to Evaluate Individual Technical Skills** (Presentation: American Society of Anesthesiologists (ASA, October 2014)

Authors: Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kupper, George Hagegeorge, Peter Hu, Evan Garofalo, Mary Njoku, Stacy Shackelford
5. **Evaluation of individual surgeon technical skills during four emergency procedures.** (Podium Presentation: Association of Military Surgeons of US (AMSUS, December 2014)

Authors: Colin F Mackenzie, Evan Garofalo, Hegang Chen, Valerie Shalin, Kristy Pugh, Stacy Shackelford, Sharon Henry, Mark Bowyer, Mark Fitzgerald, Joost Funke Kupper, George Hagegeorge, Peter Hu, Kon Mouzakis
6. **Accurate assessment of surgical skill improvements after training** (Presentation: Eastern Association of Surgery for Trauma (EAST, January 2015)

Authors: Stacy Shackelford, MD, Evan Garofalo, PhD, Valerie Shalin, PhD, Kristy Pugh, MS, Jason Pasley, DO, Babak Sarani, MD, Sharon Henry, MD, Mark Bowyer, MD, Colin Mackenzie MBChB
7. **Management of Vascular trauma by senior surgical residents: Perception does not equal reality** (presentation: Academic Surgical Congress (ASC February 2015)

Authors: Mark Bowyer, Stacy Shackelford, Evan Garofalo, Kristy Pugh, Colin Mackenzie

8. **Assessment of surgical anatomy skills in upper and lower limb vascular control and before and after training** (podium: Association for Surgical Education (April 2015))

Authors: Evan Garofalo, Stacy Shackelford, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie

9. **Mobile Platform for Assessing Emergency Trauma Surgical Skill Performance.** (poster: Association for Surgical Education (April 2015))

Authors: Colin Mackenzie, Stacy Shackelford, Evan Garofalo, Hegang Chen, Jason Pasley, Sharon Henry, George Hagegeorge, Kristy Pugh, Mark Bowyer. STAR and Shock Trauma Center, Departments of Anatomy and Epidemiology, University of Maryland School of Medicine, USAF and USUHS Bethesda MD

10. **Surface anatomy in the performance of a lower extremity fasciotomy before and after training** (poster: Federated American Societies for Experimental Biology, American Association of Anatomists (FASEB, AAA March 2015))

Authors: Evan Garofalo, Stacy Shackelford, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie

Peer Reviewed journal articles

1. **Development and validation of trauma surgical skills metrics: Preliminary assessment of performance after training** (PUBLICATION: Journal of Trauma (2015))

Authors: Stacy Shackelford, Evan Garofalo, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie

2. **Management of vascular trauma by senior surgical residents: Perception does not equal reality** (PUBLICATION *in review*: Journal of Surgical Research (2015))

Authors: Mark Bowyer, Stacy Shackelford, Evan Garofalo, Kristy Pugh, Colin Mackenzie



DEPARTMENT OF THE ARMY
U.S. ARMY MEDICAL RESEARCH ACQUISITION ACTIVITY
820 CHANDLER STREET
FORT DETRICK MD 21702-5014

January 15, 2015

SUBJECT: BA150077 - "Refreshing Combat Surgical Skills for Vascular Control"

Colin MacKenzie
University of Maryland, Baltimore
419 Redwood Street, Suite 225
Baltimore, MD 21201

Dear Dr. MacKenzie:

You are invited to submit a proposal/application to the Fiscal Year 2015 (FY15) Department of Defense (DoD) Broad Agency Announcement (BAA) for Extramural Medical Research. The reviewers found your pre-proposal/pre-application to be of interest to US Army Medical Research and Materiel Command (USAMRMC) programs aimed at the solution of medical problems of military importance.

In accordance with the Federal Acquisition Regulations, the USAMRMC advertised for research and development proposals/applications using a BAA. Since your proposal/application will be submitted after October 1, 2014, you are required to submit it under the FY15 BAA (released on October 1, 2014 at www.grants.gov under CFDA 12.420) and to use the forms identified in the announcement. Attempts to submit any forms from a previous iteration of the DoD BAA will be rejected by Grants.gov.

In addition, your proposal/application must include the requisite components, comply with preparation instructions, include the log number BA150077, and be submitted by 11:59 p.m. Eastern time on April 15, 2015 as described in the FY15 BAA and General Submission Instructions.

Please note that your proposal/application may be rejected for administrative reasons without further review if the budget or research project as described in the pre-proposal/pre-application differs significantly from the full proposal/application.

Based on the information provided in the pre-application, you should address the following in your application: the inclusion of a trauma and combat surgeon or equivalent expert to advise on this study, detailed statistical design including power analysis accounting for recruitment and retention of subjects, and justification for the proposed period of performance.

Applications must be submitted by the Authorized Organizational Representative through Grants.gov (www.grants.gov). For synopsis details, full BAA, and proposal/application package including instructions, go to <http://www.grants.gov/web/grants/search-grants.html> and enter Funding Opportunity Number W81XWH-BAA-15-1 under "Basic Search Criteria."

Please note that this invitation to submit a proposal/application does not assure funding. The full proposal/application will be reviewed for both scientific merit and program relevance. Please recognize that research funds are limited and proposals/applications must be highly competitive.

Your interest in the research and development activities of this organization is appreciated. Should you have questions or concerns, you may contact the Help Desk Monday-Friday 9:00-5:00 Eastern time at help@eBRAP.org or 301-682-5507.

Sincerely,



For

Laurie E. Hovermale
Chief, Business Operations Division

Copy furnished:
MCMR-RTJ

Title: Assessment of Surgical Performance: *Early Stage Assessment*

Colin F Mackenzie MB ChB
Shock Trauma Anesthesiology
Research Center (STAR),
University of Maryland School of
Medicine
cmack003@umaryland.edu



THESIS OBJECTIVES

- Review literature on measures of individual surgeon technical skills performance and identify strengths and limitations of available metrics.
- Describe how and why I intend to develop and validate the surgical performance metrics for upper and lower extremity vascular control .
- Use these metrics to show the impact of Advanced Surgical Skills Exposure for Trauma (ASSET) training on surgeon technical performance during emergency surgery vascular control procedures

THESIS HYPOTHESES

- My overall hypothesis is that surgical performance measures can be developed, and validated to demonstrate the effectiveness of ASSET training for upper and lower extremity vascular control procedures.
- *I intend to explore 3 linked hypotheses regarding the acquisition of surgical skills and means to validate performance assessments of those skills.*
-
- These three sub- hypotheses are:
- 1) Metrics derived from cognitive work and video task analyses of expert surgeons' and untrained ASSET- novice surgeons performing the three selected ASSET extremity vascular control skills will result in a useful, valid, and objective tool for assessment of acquisition of technical and non-technical skills by participants in the ASSET course, and these metrics can be correlated with instructor global rating evaluations.
- 2) Improved performance of three ASSET-based extremity vascular control skills will be demonstrated by participants evaluated by the above metrics after participation in the ASSET training curriculum using unpreserved cadaver models.
- 3) Surgeons' performance on objective skills assessment of upper and lower extremity vascular access and control procedures will correlate with anatomic knowledge (landmarks, placement of skin incision) taught in the ASSET course.
-

What is the problem? TRAINING GAP:

- Fewer graduating U.S. residents document experience with vascular trauma. [1,2] ;
- Shorter training hours since 2003 (ACGME)
- Shift to non-operative management strategies for trauma
- Prevention efforts(Belts and Bags), reduced penetrating trauma nationwide = less injury
- Resident work hour restrictions = less surgery
- *[1] J Trauma. 2003;54(1):161-3; [2] Mil Med. 1989; 154(11):581*

ASSET : A Solution for Military Surgeons

Training Gap

Performance metrics in vascular exposure Before and After

Advanced Surgical Skills Exposure for Trauma (ASSET) Training

ASSET Course developed by ACS COT

Over 600 surgeons have participated in the 6 years since started

THREE Representative ASSET Surgical Procedures included in Thesis

- ***Lower Extremity:***
- Femoral artery (SFA, CFA, PFA) injuries prevalent in Lower Extremity [1]
- ***Upper Extremity (% of 43 injuries in Iraq):***
- Axillary artery (23%), Brachial artery (58%) [2].

[1] *J Vasc Surg.* 2008; 47(6): 1259-64;

[2] *Ann Vasc Surg.* 2006; 20(4): 429-34;

Military Relevance of studying vascular control procedures

- Bleeding is the leading cause of early preventable death in military & civilian casualties.
- Difficult for military trauma surgeons to maintain proficiency in exposure and vascular control of major blood vessels
- Vascular injury in modern combat is five times that reported in previous wars [1].
- 50-70% of all injuries treated during Operation Iraqi Freedom are extremity injuries [2].
- Exsanguination from upper and lower extremity wounds is a leading cause of preventable death on the modern battlefield [3].

[1] Ann Surg. 2011; 253(6): 1184-9;

[2] J Trauma. 2006; 60 : 432-42;

[3] J Trauma 2008; 64 (suppl) s21-s 27

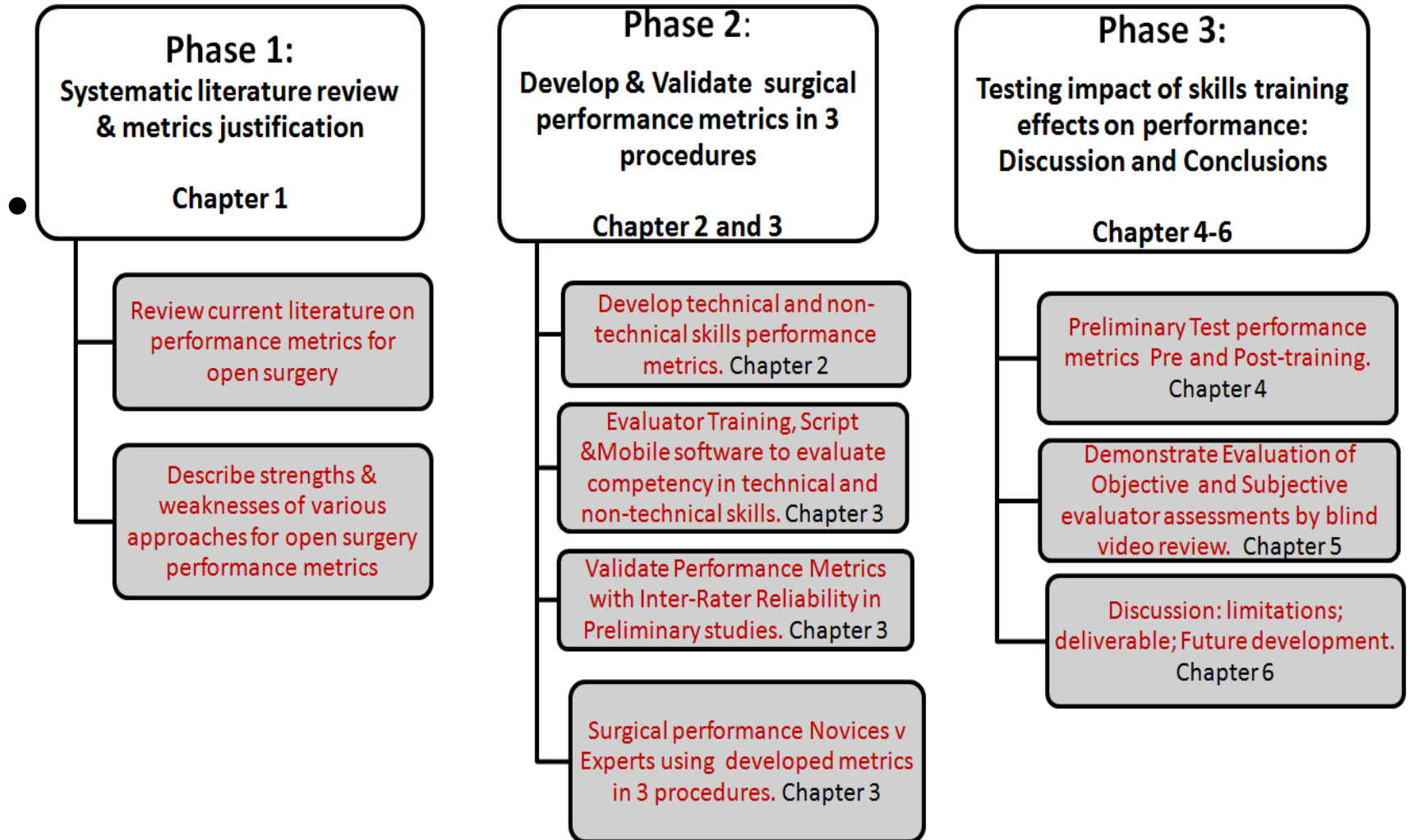
Why will this project produce useful new data?

- Objective measures of acquisition & retention combat surgical skills are lacking (OSATS[1] and others are non-combat)
- Surgeon performance metrics for upper and lower extremity vascular control procedures are lacking as is surgeon experience . *A) Major vascular repairs for trauma by graduating chief residents (ABS data) decreased on average from 5.0 in 2001-2002 to 2.1 in 2010-2011 over the course of a residency in general surgery [2] .B) Exposures of the brachial artery by chief residents in 2010-2011 was 0.0.*
- Although over 600 surgeons have taken ASSET course and it is a course required for graduation from Surgical Training programs in US, and is incorporated into the Emergency War Surgery course, ASSET training has never been validated.
- [1] *Br J Surg* 1997;84:273-8
- [2] http://www.acgme.org/residentdatacollection/documentation/statistical_reports.asp;

Timeline and Phases of OVERALL 3 yr Study

Phase 1	Year One												Year Two												Year Three																										
Month of study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36															
Task A	SME Cognitive Work and Task Analysis Model Construct Validity, Validate & Modify TRR n= 10 Experts & 10 Novices																																																		
Phase 2 –Untrained Subjects – test base line skills, take ASSET course, test post course, reevaluate at either 12 or 18 months (n=40)																																																			
Task B-1 (subjects 1-10)																																																			
Task B-2 (Subjects 11-20)																																																			
Task B-3 (subjects 21-30)																																																			
Task B-4 (Subjects 31-40)																																																			
Phase 3 – bring back previously trained ASSET surgeons and retest (n= 40)																																																			
Subjects return at intervals from 2-5 years after ASSET course													Subjects asked to return and perform ASSET skills with scheduling to coincide with intervals of 2-5 years from original course																																						
Data Analysis and report																																										Data analysis & report									

Project Description & 3 Phases of 2yr THESIS

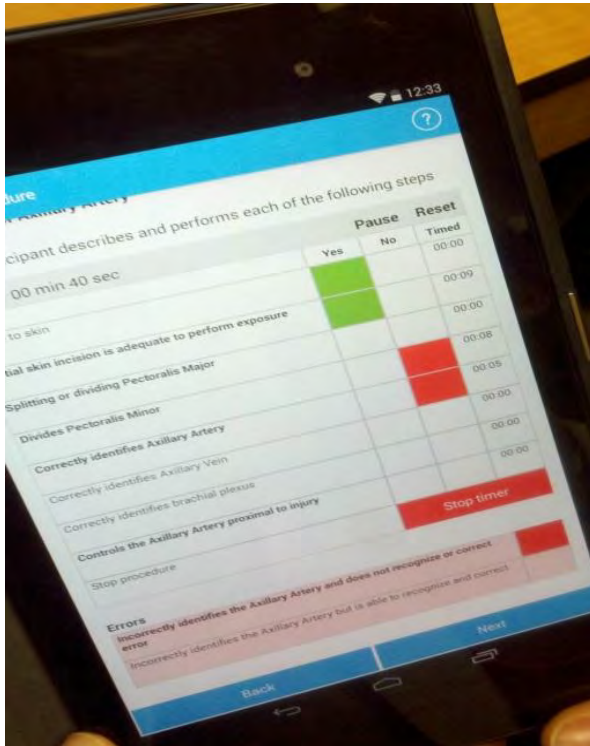


Intended Overall Outcome

Demonstrable trauma surgical skills performance metrics that can show benefit of ASSET training

METHODS –

Phase 2 Thesis:



Incorporate Script and Evaluation Metrics into **Mobile Tablet** for 'real-time' evaluations and data collection. **Mobile Tablet Showing App, with Script, Case History, and Evaluation metrics. Summary print out.**

- **Video Record 10 ASSET Instructor Experts** "Talk Aloud" explaining performance during the ASSET procedures, knowledge needed, technical details and common errors.
- **Consensus Conference** among experts: identify essential expertise, agree on terms and relative importance of features of expert performance. **Develop a standard script of case histories in collaboration with experts** to assess knowledge, anatomy and technical skills of the 3 procedures, agree on common errors and correct technical Skills = **Evaluation Metrics**
- **Video Record 10 Non-ASSET Trained novices with Standard Script. :**
- **Train Evaluators:** Web-based training with Handbook:
- **Validate Metrics with Blinded video review** of random expert and novice video clips by 5 evaluators. Apply **Inter-Rater Reliability** statistics using Intra Class correlation coefficient.

Intra Class Correlation Coefficients and Technical Skills assessed



Table 1. Technical skills with intra-class correlation coefficients.

		Consistency		Agreement	
	Measure	ICC	95% CI	ICC	95% CI
1	Exposes arteries by dissecting directly on anterior surface	Single	0.5 0.17 to 0.9	0.53	0.19 to 0.87
		Average	0.84 0.51 to 0.97	0.85	0.54 to 0.97
2	Manipulates artery by grasping adventitia*	Single	0.2 -0.07 to 0.72	0.21	-0.07 to 0.74
		Average	0.55 -0.48 to 0.93	0.57	-0.51 to 0.93
3	Uses instruments properly*	Single	0.3 0.07 to 0.63	0.31	0.07 to 0.90
		Average	0.68 0.27 to 0.9	0.69	0.28 to 0.90
4	Positions body to use instruments to best advantage	Single	0.41 0.18 to 0.7	0.38	0.16 to 0.67
		Average	0.78 0.52 to 0.92	0.76	0.49 to 0.91
5	Proceeds at an appropriate pace with economy of movement	Single	0.8 0.64 to 0.92	0.78	0.61 to 0.91
		Average	0.95 0.9 to 0.98	0.95	0.89 to 0.98
6	Handles tissue well with minimal damage	Single	0.36 0.09 to 0.71	0.36	0.099 to 0.71
		Average	0.74 0.34 to 0.93	0.74	0.35 to 0.93
7	Creates an adequate visual field using retractors for procedure	Single	0.78 0.59 to 0.92	0.78	0.59 to 0.92
		Average	0.95 0.88 to 0.98	0.95	0.88 to 0.98
8	Communicates clearly and consistently	Single	0.77 0.47 to 0.96	0.78	0.49 to 0.96
		Average	0.94 0.82 to 0.99	0.95	0.83 to 0.99
9	Performs procedure without unnecessary dissection	Single	0.72 0.52 to 0.88	0.73	0.54 to 0.87
		Average	0.93 0.85 to 0.97	0.93	0.85 to 0.98
10	Continually progresses toward the end goal	Single	0.69 0.48 to 0.86	0.7	0.49 to 0.87
		Average	0.92 0.82 to 0.97	0.92	0.83 to 0.97

Methods & Prelim Results. Phase 3:

- 1) Video record 39 non-trained surgeons performing 3 procedures before and within 2 weeks of a 1 day ASSET course training that includes the 3 procedures (among 47 total) taught by independently trained ASSET course Instructors.
- 2) Randomly arrange video clips of 12 of 39 trainees before and after training Have blinded trained evaluators assess technical skills performance data, before and after training by video review
- 3) compare video evaluations to assessments made by two co-located evaluators. While the procedures were performed on unpreserved cadavers ,
- 4) Select 4 trainees by a double randomization selection to test for evaluator learning and bias among 5 evaluators who will all review the sam candidate videos

Table 3: Comparison of Anatomic Knowledge and Surgical Performance before and After Training for Axillary, Brachial and Femoral Artery Vascular Control:

Correct Landmarks & Incision related to successful artery identification & control

		Procedure				
		Axillary Artery	Brachial Artery	Femoral Artery		
		mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD
Surface Landmarks (% correct)	Pre	35 $\pm$ 4	49 $\pm$ 3	56 $\pm$ 3		
	Post	74 $\pm$ 4	65 $\pm$ 3	81 $\pm$ 3		
	diff	39 ***	15 **	24 ***		
Adequate Incision %	Pre	-1.2 $\pm$ 0.3	1.1 $\pm$ 0.4	-0.7 $\pm$ 0.3		
	Post	1.6 $\pm$ 0.3	2.9 $\pm$ 0.6	1.2 $\pm$ 0.3		
	diff	2.9 ***	0.6 **	1.9 ***		
Procedure Time (mins)	Pre	11.7 $\pm$ 0.6	10.4 $\pm$ 0.7	16.6 $\pm$ 0.7		
	Post	7.9 $\pm$ 0.6	9.5 $\pm$ 0.7	13.6 $\pm$ 0.7		
	diff	-3.8 ***	-0.8	-2.9 ***		
Correct Artery Identification	Pre	-0.2 $\pm$ 0.3	0.15 $\pm$ 0.4	-0.7 $\pm$ 0.4	CFA†	SFA†
	Post	2.3 $\pm$ 0.5	0.9 $\pm$ 0.4	1.6 $\pm$ 0.4	0.2 $\pm$ 0.4	3.5 $\pm$ 0.07
	diff	2.5 ***	0.8	2.3 ***	3.4 ***	1.8 $\pm$ 0.3
Successful Artery Control %	Pre	-0.7 $\pm$ 0.3	0.2 $\pm$ 0.4	-0.4 $\pm$ 0.3	-0.1 $\pm$ 0.4	-0.6 $\pm$ 0.4
	Post	1.9 $\pm$ 0.4	1.3 $\pm$ 0.4	1.8 $\pm$ 0.4	3.0 $\pm$ 0.6	1.4 $\pm$ 0.4
	diff	2.5 ***	1 *	2.3 ***	3.1 ***	2.1 ***

†CFA: Common Femoral Artery; SFA: Superficial Femoral Artery; PFA: Profunda Femoral Artery;

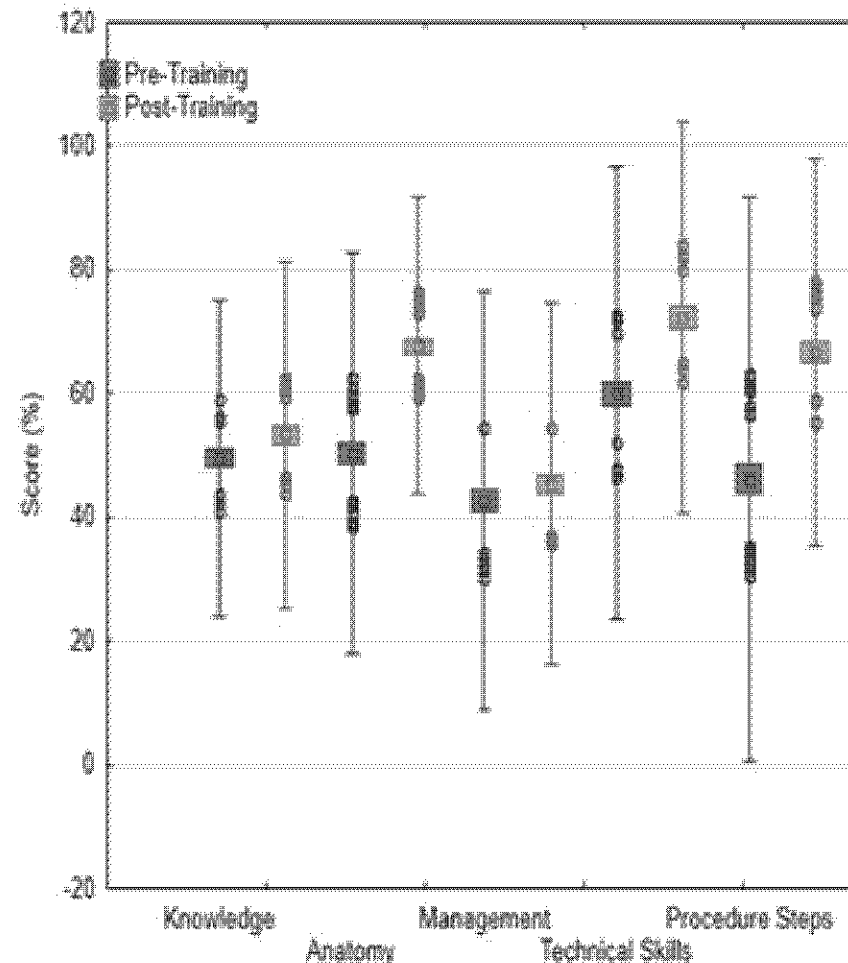
% Binary data analysed with General Linear Mixed Model, logistic model

Significance of difference demarked as $\alpha=0.05$: *** $\alpha\leq 0.0001$: ** $\alpha\leq 0.001$: * $\alpha\leq 0.05$

Figure 1: Testing Before/After ASSET training n = 12

Differences all significant

- 3 vascular exposure metrics improved 14% after training.
- Procedural steps scores increased 21%
- Surgical Technical Skills increased 12%
- Overall knowledge improved 3%
- Anatomic knowledge improved 18%
- Management knowledge improved 2%
- Time to completion decreased 4.3 min (13.4- 9.1) **One Third !**



Publications/Presentations to Date

- **1) The assets of ASSET: surgical performance confidence through an anatomy and skills review course for surgeons**
Evan Garofalo, Stacy Shackelford, Megan Holmes, Colin Mackenzie, Mark Bowyer. American Association of Anatomists
FASEB academic meeting April 2014
- **2) Mobile Platform to Evaluate Individual Surgeon Technical Skills**
Colin F Mackenzie, Mark Fitzgerald, Kon Mouzakis, Joost Funke Kupper, George Hagegeorge, Peter Hu, Evan Garofalo, Mark Bowyer, Sharon Henry, Stacy Shackelford Military Health Services Research Symposium Aug. 2015 Ft Lauderdale FL
- **3) Development of a Trauma Readiness Metric Score for Surgeons**
Evan Garofalo, Stacy Shackelford, Valerie Shalin, Megan Holmes, Jason Pasley, Elliot Jessie, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie (Presenter) Military Health Services Research Symposium Aug 2015 Ft Lauderdale FL
- **4) Evaluation of Individual Surgeon Technical Skills During Four Emergency Procedures.**
Colin Mackenzie Podium lecture Assoc Military Surg of US Nov 2014 Washington DC
- **5) Evaluation of Surgeon Technical Skills before and After training.**
Colin Mackenzie lecture: Trauma and Emergency Care Research Seminar Series Oct 15th 2014, University of Maryland School of Medicine
- **6) Assessment of surgical anatomy skills in upper and lower limb vascular control and before and after training**
Evan Garofalo, Stacy Shackelford, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie (Presenter) Association for Surgical Education Abstract Podium Presentation Accepted
- **7) Mobile Platform for Assessing Emergency Trauma Surgical Skill Performance.**
Colin Mackenzie (Presenter), Stacy Shackelford, Evan Garofalo, Hegang Chen, Jason Pasley, Sharon Henry, George Hagegeorge, Kristy Pugh, Mark Bowyer. STAR and Shock Trauma Center, Departments of Anatomy and Epidemiology, University of Maryland School of Medicine, USAF and USUHS Bethesda MD Association for Surgical Education Abstract Poster Accepted
- **8) Surface anatomy in the performance of a lower extremity fasciotomy before and after training**
Evan Garofalo (Presenter), Stacy Shackelford, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin Mackenzie FASEB 2015 Accepted
- **9) Mark. W. Bowyer (Presenter), Stacy. A. Shackelford, Evan. Garofalo, Kristy. Pugh, Colin. Mackenzie** Management of Vascular Trauma by Senior Surgical Residents: Perception Does Not Equal Reality. Abstract Podium presentation Acad SurgCongress 2015
- **10) Papers Accepted :**
Stacy Shackelford, Evan Garofalo, Valerie Shalin, Kristy Pugh, Hegang Chen, Jason Pasley, Babak Sarani, Sharon Henry, Mark Bowyer, Colin F Mackenzie **DEVELOPMENT AND VALIDATION OF TRAUMA SURGICAL SKILLS METRICS: PRELIMINARY ASSESSMENT OF PERFORMANCE AFTER TRAINING** Accepted by J of Trauma December 2014

Team / Roles & Responsibilities

Retention and Assessment of Surgical Performance

(RASP) TEAM: Colin Mackenzie (PI), COL Stacy Shackelford FACS, COL (Rtd) Mark Bowyer FACS, Sharon Henry FACS, Evan Garafalo PhD

Valerie Shalin PhD (Psychologist/Human Factors).

Evaluators: TEAM + Jason Pasley FACS, Babak Sarani FACS, Mayur Narayan FACS , Elliot Jessie FACS, Amechi Anazodo MD, Brandon Bonds MD

Script Readers: Megan Holmes, Kristy Pugh , Nicole Squyres, Alexys Monoson

Conflict of Interest Statement

- This research and development project was conducted by the University of Maryland, School of Medicine and was made possible by a cooperative agreement which was awarded and administered by the U.S. Army Medical Research & Materiel Command (USAMRMC) and the Congressionally Directed Medical Research Program Office at Fort Detrick, Md under Contract Number: W81XWH-13-2-0028 for \$ 2 Million over 3 years 2014 – 2017 from which Colin Mackenzie's work on this Thesis is supported**

Supporting data

Table 1: Median confidence with surgical anatomy (Phase II)

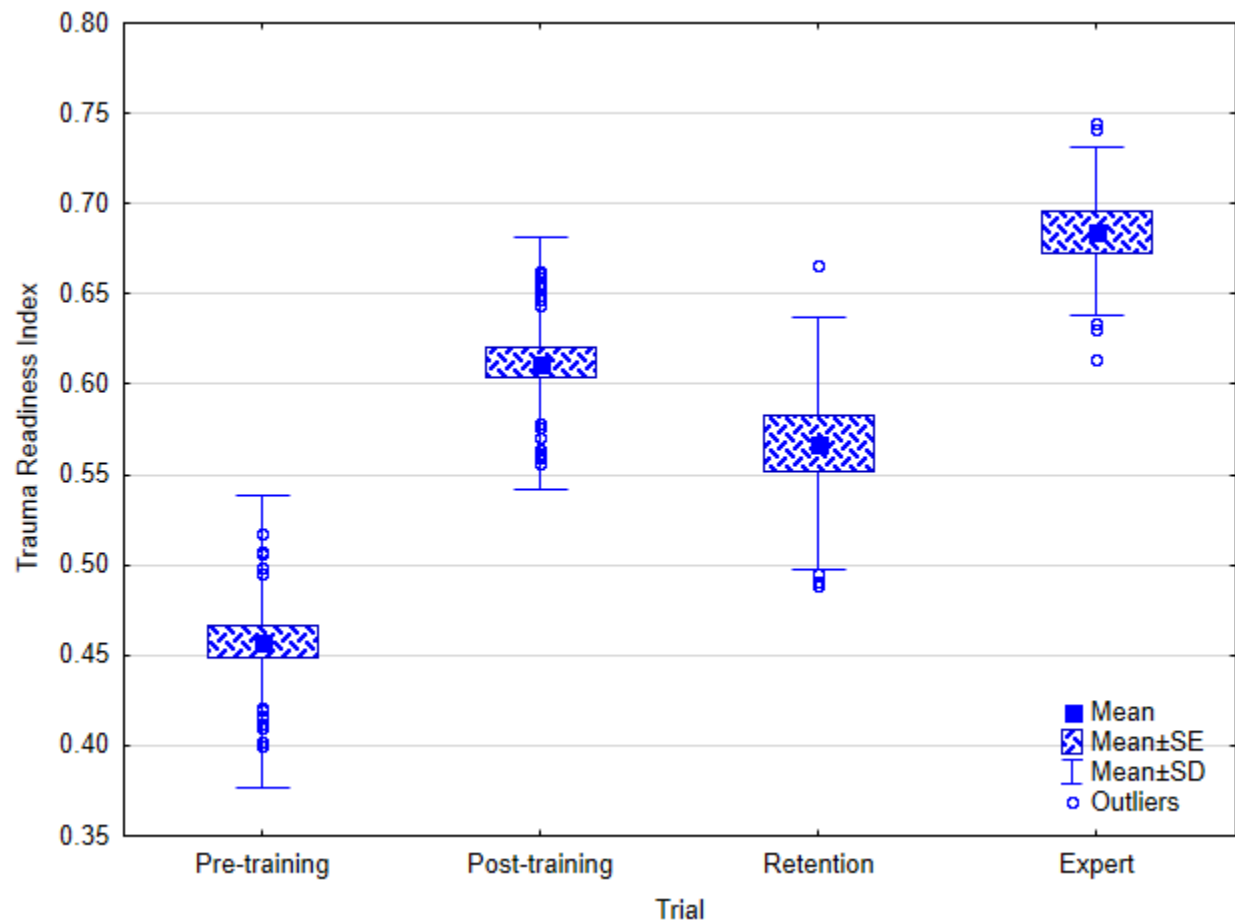
Median reported levels of confidence with the surgical anatomy and comfort to performance surgical procedures independently before and after ASSET training (n=23)

		Pre-Training		Post-Training	
		Pre- evaluation	Post- evaluation	Pre- evaluation	Post- evaluation
Understanding of the surgical anatomy:	Shoulder/ axillary region	2.5	2	4	4
	Arm	3	3	3.5	4
	Forearm	3	3	3	4
	Inguinal region	4	4	4	4
	Lower extremity	3	4	4	4
Performing surgical procedures for traumatic injury independently:	Shoulder region for traumatic injury	2	2	3	4
	Arm for traumatic injury	2	3	4	4
	Forearm for traumatic injury	2	3	4	4
	Inguinal region for traumatic injury	3	4	4	4
	Lower extremity fasciotomy for traumatic injury	3	3	4	4

These data indicate that surgeons are have moderate confidence in their understanding of the relevant anatomy before beginning ever performing the procedures. Their confidence increases after the initial procedure performance and continues to increase following their post-training evaluation.

Phase 2 surgeons have low to moderate confidence initially in their ability to perform procedures independently but they gain higher levels of confidence after deliberate practice performing the procedures.

Figure 1: Mean Trauma Readiness Index by experimental trial



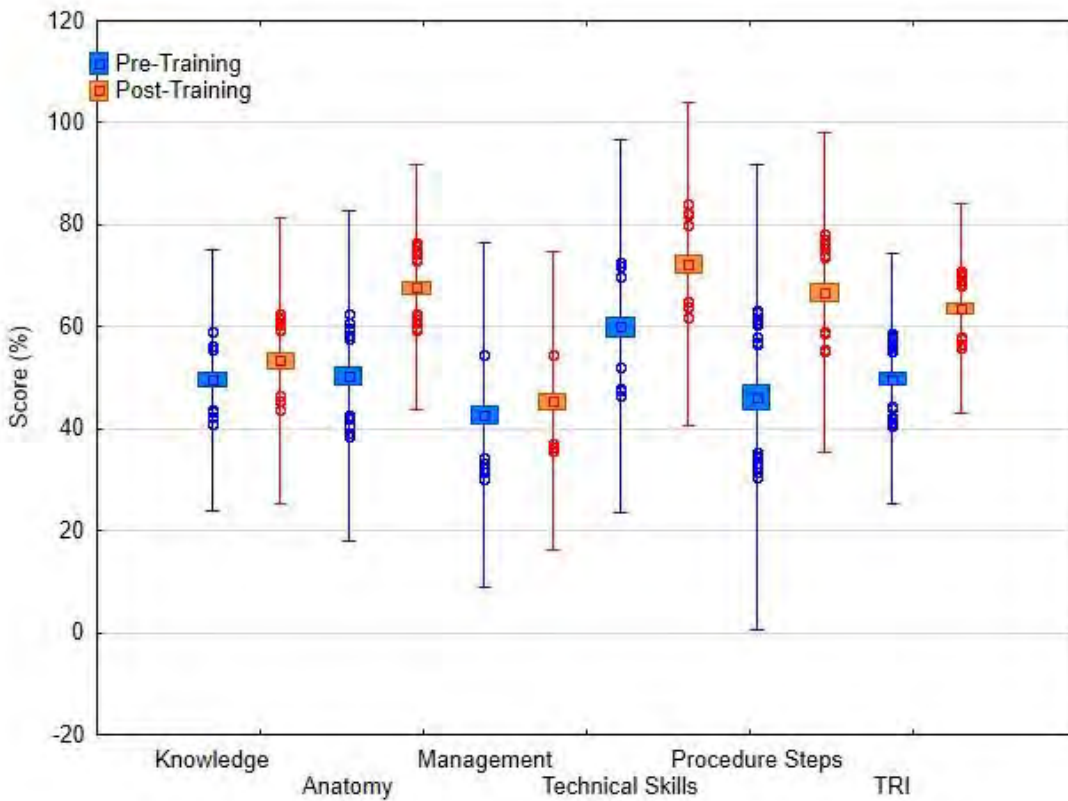
These data indicate a significant improvement after training, a lower score for surgeons 2 to 5 years after training and a significantly higher score for Expert surgeons.

Table 2: Pair wise comparisons of TRI between surgeon types

(Tukey unequal n, $\alpha=0.05$, red indicates significant comparisons)

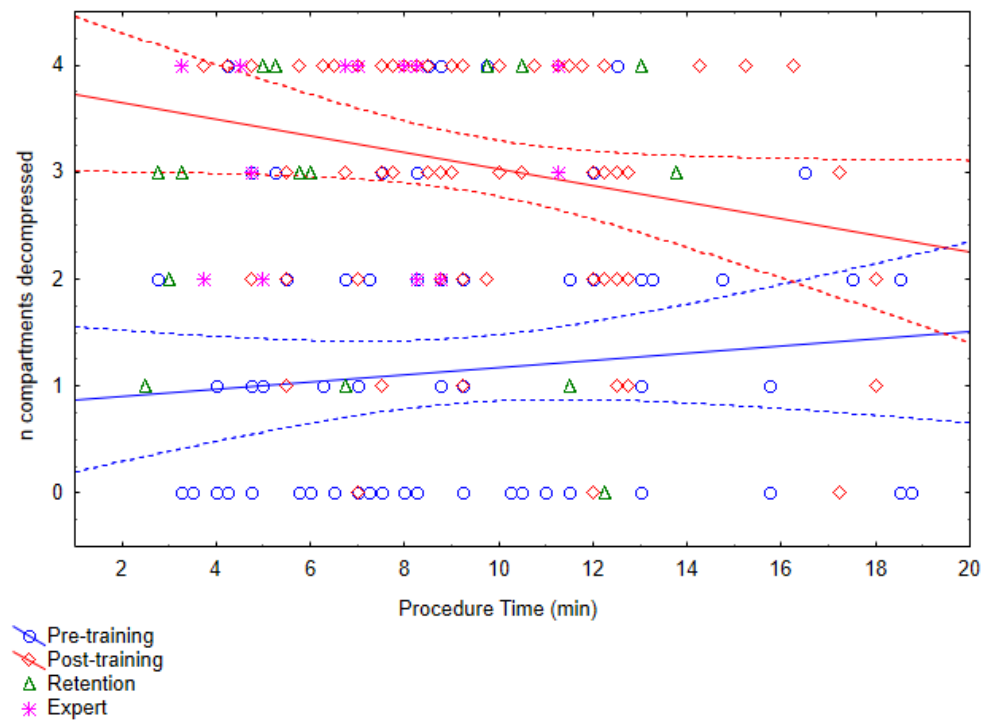
Trial	Mean TRI	Pair-wise Trial		
		Pre-training	Post-training	Retention
Pre-training	0.46			
Post-training	0.61	0.000008		
Retention	0.57	0.00004	0.2	
Expert	0.68	0.000008	0.02	0.00004

Figure 2: Score (%) for individual components of TRI before and after training
(box plot: mean, 1 SE, and whiskers=2 SD)



These data indicate that the greatest improvement after training is seen for anatomical knowledge, technical skills, and procedural steps.

Figure 3: Successful compartment decompressions among surgeon types



This figure indicates the number of successfully decompressed compartments during a 2 incision 4 compartment lower extremity fasciotomy by time performed by surgeons in each experimental group. Fit lines with 95% CI are shown for Pre and Post-training residents only. Post-training surgeons and experts tend to decompress more compartments in about the same amount of time as Pre-trained surgeons decompress fewer compartments (fail to decompress the compartments).

Figure 4: Individual Procedure Score (IPS) and TRI for all four procedures
(box plot: mean, 1 SE, and whiskers=1 SD)

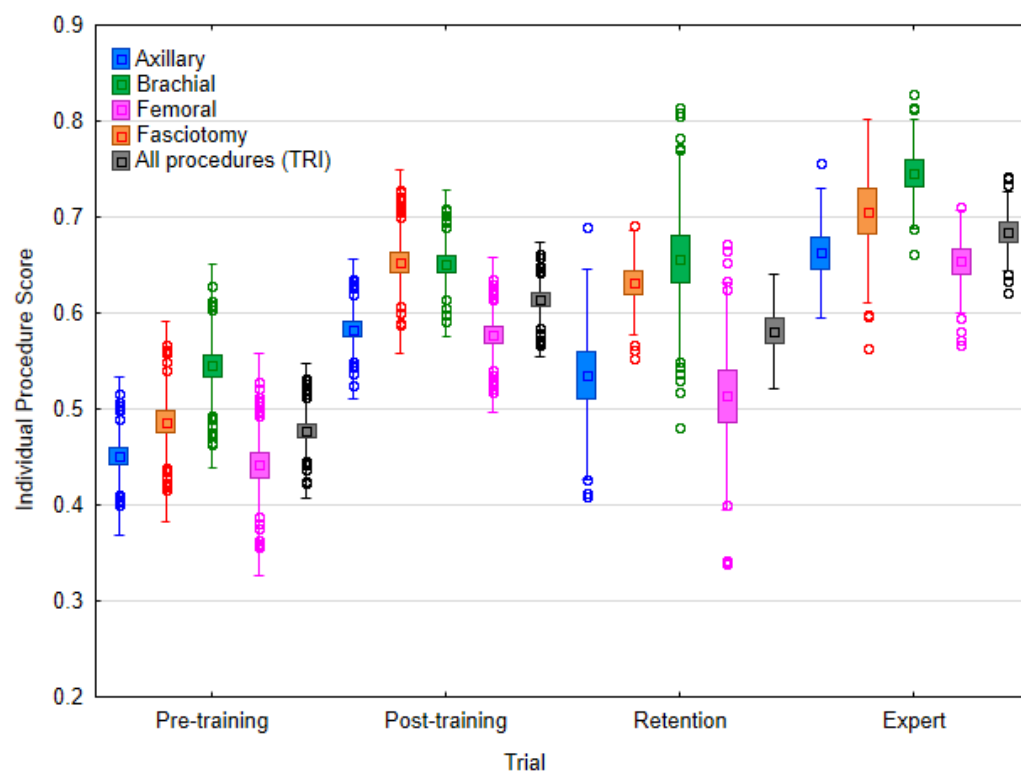


Table 5: Expenditures for the quarter ending 02/28/15

NEW QUARTER (12/01/2014 - 02/28/2015)	
Cost Elements	Quarter Total
Personnel	\$93,198.37
Fringe Benefits	\$19,085.25
Supplies	\$776.00
Equipment	-\$11,400.00
Travel	\$3,238.84
Other Direct Costs	\$37,089.89
<i>Subtotal</i>	\$141,988.35
Indirect Costs	\$39,880.96
Fee	\$0.00
Total Expenditures	\$181,869.31

Table 6: Current Personnel Effort

Name	Role	Effort
Mackenzie, Colin	Principal Investigator	20%
Hu, Peter	Co-Investigator	5%
Hagegeorge, George	Senior Technician	30%
Chen, Hegang	Statistician	2%
Garofalo, Evan	Research Coordinator	100%
Kristy Pugh	Lab tech/Research asst	100%
Cris Imle	Scheduling Assistant	100%

