

AWARD NUMBER: W81XWH-19-1-0522

TITLE: Nano-pulsed Laser Optoacoustic Therapy for Pre-treatment and Post-treatment of Traumatic Brain Injury

PRINCIPAL INVESTIGATOR: Maria-Adelaide Micci

CONTRACTING ORGANIZATION: University of Texas Medical Branch, Galveston, TX

REPORT DATE: October 2020

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Development Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
Distribution Unlimited

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE October 2020			2. REPORT TYPE Annual			3. DATES COVERED 30Sep2019-29Sep2020		
4. TITLE AND SUBTITLE Nano-pulsed Laser Optoacoustic Therapy for Pretreatment and Posttreatment of Traumatic Brain Injury						5a. CONTRACT NUMBER W81XWH-19-1-0522		
						5b. GRANT NUMBER		
						5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Maria-Adelaide Micci E-Mail: mmicci@utmb.edu						5d. PROJECT NUMBER		
						5e. TASK NUMBER		
						5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The University of Texas Medical Branch, Galveston						8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Development Command Fort Detrick, Maryland 21702-5012						10. SPONSOR/MONITOR'S ACRONYM(S)		
						11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited								
13. SUPPLEMENTARY NOTES								
14. ABSTRACT Traumatic brain injury (TBI) represents both an acute and a chronic medical challenge among service members and veterans. The purpose of this research is to demonstrate, in a rodent model, that a unique non-invasive nano-pulsed laser optoacoustic therapy (NPLT) is a promising pre-treatment for military personnel at high risk of combat-related TBI and a promising treatment after combat-related TBI, with the goal of limiting onset and progression of neuropathology and cognitive impairment. During the first year of this grant (10/01/19-09/30/20), we have prepared and submitted the animal protocol to USAMRDC Animal Care and Use Review Office (ACURO) and after receiving approval on January 10, 2020, we have completed the behavioral experiments for Aim 1 and found that pre-treatment with NPLT reduces cognitive impairments in the rats subjected to blast-induced brain injury. We have additionally initiated histopathological analyses for Aim 1 and behavioral testing for Aim 2 as originally planned in the approved proposal.								
15. SUBJECT TERMS Traumatic Brain Injury; Blast Injury; Non-invasive Therapy; Nano-pulsed Optoacoustic Laser Therapy; Neuroprotection								
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT		18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON		
a. REPORT	b. ABSTRACT	c. THIS PAGE	Unclassified		16	USAMRMC		
Unclassified	Unclassified	Unclassified				19b. TELEPHONE NUMBER (include area code)		

TABLE OF CONTENTS

	<u>Page</u>
1. Introduction	4
2. Keywords	4
3. Accomplishments	4
4. Impact	8
5. Changes/Problems	9
6. Products	10
7. Participants & Other Collaborating Organizations	13
8. Special Reporting Requirements	15
9. Appendices	16

1. INTRODUCTION:

Traumatic brain injury (TBI) represents both an acute and a chronic medical challenge among service members and veterans. We have reported that transcranial application of a unique non-invasive nano-pulsed laser optoacoustic therapy (NPLT) stimulates the expression of specific factors which increase neuronal survival after TBI. The purpose of this research is to demonstrate, in a rodent model, that NPLT is a promising pre-treatment for military personnel at high risk of combat-related TBI and a promising treatment after combat-related TBI, with the goal of limiting onset and progression of neuropathology and cognitive impairment.

2. KEYWORDS:

Traumatic Brain Injury; Blast injury; Non-invasive Therapy; Nano-pulsed Optoacoustic Laser Therapy; Neuroprotection

3. ACCOMPLISHMENTS:

What were the major goals of the project?

- **Goal 1-** Preparing protocol of animal use for ACURO review and approval.
- **Goal 2:** Testing preventative NPLT efficacy for bTBI (**Aim 1**)
 - **Major Task 1:** NPLT treatment and blast TBI on 48 rats (**100% completed**)
 - **Major Task 2:** Behavioral assessments (**100% completed**)
 - **Major Task 3:** Biochemical and histological analyses (**10% completed**)
- **Goal 3:** Testing NPLT efficacy for repetitive bTBI (**Aim 2**)
 - **Major Task 4:** NPLT treatment and blast TBI on 48 rats (**25% completed**)
 - **Major Task 5:** Behavioral assessments (**25% completed**)
 - **Major Task 6:** Biochemical and histological analyses (**2.5% completed**)

What was accomplished under these goals?

Major activity related to Goal 1- We have submitted the animal protocol to ACURO for review and received approval.

Major activities related to Goal 2/ Major Task 1: NPLT treatment and blast TBI

Adult (2 months old) male, Sprague–Dawley rats (Charles River Laboratories, Wilmington, MA) were randomized to receive NPLT or no treatment and further randomized to be subjected to blast TBI (bTBI) or Sham Injury (N=12 rats/experimental group)

NPLT treatment. NPLT was delivered transcranially to the shaved rat head through a 3 mm diameter, specially developed, fiber-optic bundle system positioned directly on the head and held in place using a stereotaxic holder (Figure 1). In order to treat the entire brain, NPLT will be delivered transcranially to two sites (one on each hemisphere, 5 minutes per site).

Blast TBI model. Blast TBI (bTBI) was produced by an Advanced Blast Simulator (ABS), a shock tube designed to circumvent some of the problems associated with experimental blast research. Specifically, the ABS is equipped with a reflected wave suppressor that prevents reflection of pressure waves (produced when the primary blast wave interacts with either the closed or the open end of the tube back) into the specimen chamber. Moreover, the divergent area driver chamber and expansion section of the ABS are designed to produce a shock waveform that closely reproduce blast injury in combatants (Figure 2).

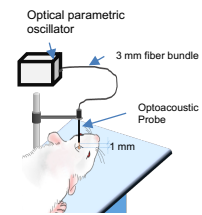


Figure 1. Nano-pulsed laser therapy (NPLT) is delivered directly to shaved head under mild anesthesia. The optical parametric oscillator delivers the pulsed laser through a 3 mm fiber bundle attached to an optoacoustic probe that is placed noninvasively on top of the rat's head.

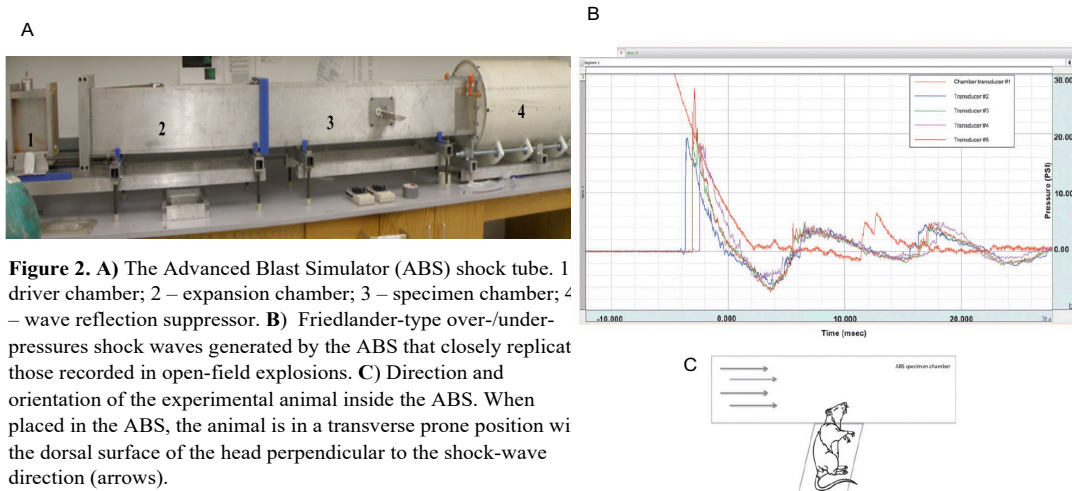


Figure 2. A) The Advanced Blast Simulator (ABS) shock tube. 1 driver chamber; 2 – expansion chamber; 3 – specimen chamber; 4 – wave reflection suppressor. B) Friedlander-type over-/under-pressures shock waves generated by the ABS that closely replicate those recorded in open-field explosions. C) Direction and orientation of the experimental animal inside the ABS. When placed in the ABS, the animal is in a transverse prone position with the dorsal surface of the head perpendicular to the shock-wave direction (arrows).

Rats were anesthetized (4% isoflurane), intubated and ventilated (2.0% isoflurane) in O₂/room air (80:20) using a volume ventilator (Small Animal Ventilator, Harvard Apparatus, Inc., Holliston, MA). Core body temperature was monitored using a rectal telethermometer (Thermalert Monitoring Thermometer, Physitemp Instruments, Inc., Clifton, NJ) and maintained within normal limits using a thermostatically controlled water blanket (Mul-T-Pad Temperature Therapy Pad, Gaymar Industries, Inc., Orchard Park, NY). After intubation, the scalp was shaved, foam plugs placed in each ear, and the animal was secured on the specimen tray with Velcro straps in a transverse prone position with the head supported at right angles to the direction of the shockwave by a leather sling suspended between two supports. When the specimen tray is placed in the ABS, only the rat's head is exposed to the shockwave (Figure 4C). After the rat was secured to the specimen tray, the isoflurane was temporarily discontinued, the ventilator hoses are detached but the rat remains intubated, the specimen tray is locked into the ABS and, at the return of a withdrawal reflex to paw pinch, the rat is subjected to bTBI (20-24 psi, 110-160 kPa) or sham injury. After injury, the animal was removed from the ABS, the duration of suppression of the righting reflex was recorded, the animal was reconnected to the ventilator, and anesthesia with isoflurane resumed. For all sham animals, the preparatory procedure previously stated was followed, but the rat was not subjected to bTBI.

During the current reporting period we have completed animal work- treatments (NPLT or Sham), injuries (bTBI or Sham injury) on a total of 48 rats (12 rats/experimental group).

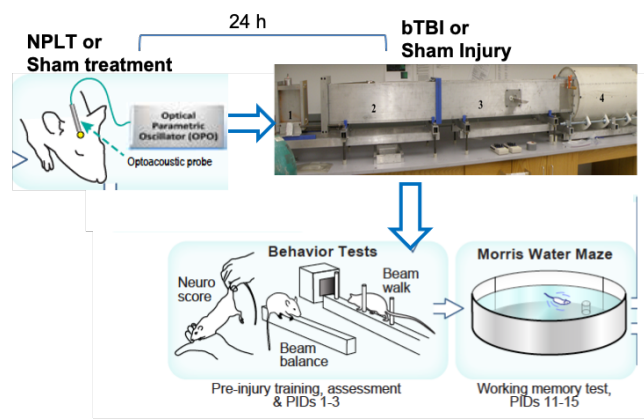
Major activities related to Goal 2/ Major Task 2: Behavioral assessments

Rats were acclimated to handling for five days and pre-trained to neurological, balance, and motor coordination tests for two days prior to receiving bTBI or sham injury. All behavioral measures were conducted by an observer blinded to the experimental groups. Gross vestibulomotor function and fine motor coordination were assessed on post-injury days (PIDs) 1 – 3 using a short neurological assessment, beam-balance and beam-walk tasks and cognitive function was assessed on PIDs 11 – 15 using a working memory version of the water maze (Figure 3).

Neuroscore. The following reflex tests were administered in order and repeated three times. A normal response received a score of 0 while an abnormal response received a score of 1 for each trial of each test for a total possible score of (7 x 3 = 21), the higher the score, the greater the deficit.

1. Forelimb Flexion Test (0-1)
2. Hind Limb Flexion Test (0-1)
3. Visually Triggered Placing Test (0-1)
4. Contact Triggered Placing Test, right (0 - 1)
5. Contact Triggered Placing Test, left (0 - 1)
6. Hind Paw Grasping Reflex Test, right (0-1)
7. Hind Paw Grasping Reflex Test, left (0-1)

Figure 3. Behavioral Assessments



Beam balance. Rats underwent one training session 24h before and one pre-assessment test on the day of the blast injury or sham procedure. The rats were trained to balance for 60 s on a short wooden beam (50 x 1.5 x 4 cm) raised 90 cm off the floor. Once the rats were able to remain on the beam, they were evaluated for three consecutive trials per session and rated using a six-point scale:

1. Balances with steady posture (grooms, climbs barrier)
2. Balances with unsteady posture (grasps sides of beam and/or has shaky movements)
3. Hugs the beam or slips or spins on the beam
4. Attempts to balance but falls off after 10 seconds.
5. Drapes over or hangs from the beam, falls off in less than 10 seconds
6. Falls off, making no attempt to balance or hang onto the beam

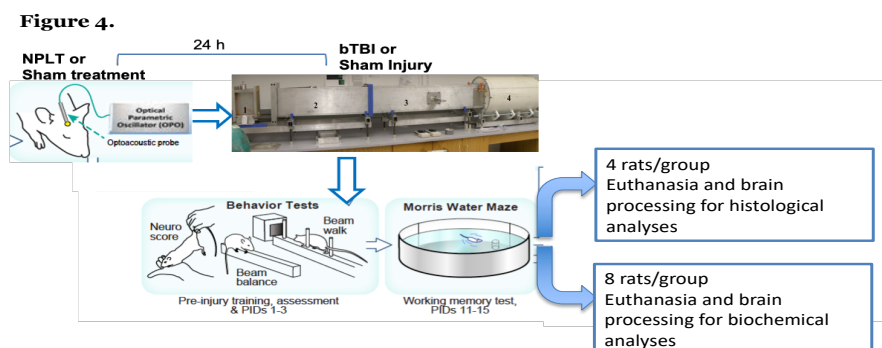
Beam walk. Animals were trained to traverse a wooden beam (100 x 2.5 x 4.0 cm) elevated 1 m above the floor. Four steel pegs were spaced at equal distances along the top and a darkened goal box was positioned at the far end of the beam. Once trained, the rats were timed during three consecutive trials, with time to reach the goal box as the primary endpoint. On the day of injury rats underwent a pre-injury assessment.

Working memory version of the Morris water maze test. Rats were placed in a tank filled with water to a level that was 2 cm higher than the hidden platform. Rats were assigned four starting points and four platform locations in a balanced order to avoid starting points too close to the platform. For Trial 1, rats were placed in the tank and allowed 120 s to find the platform. Once on the platform, the rats were allowed 15 s to rest and then were placed in the tank again from the same starting point to begin Trial 2. They were again allowed 120 s to find the platform. Rats were rested 4 min in a heated enclosure before starting a second pair of trials which used different platform and starting locations. Rats received four pairs of trials daily for five consecutive days. All rats received the same sequence of starting points and platform locations.

During the current reporting period we have completed behavioral testing on a total of 48 rats. Data analysis is in progress.

Major activity related to Goal 2/ Major Task 3: Biochemical and histological analyses

At the end of the water maze test one cohort of rats were euthanized using 2-3% isoflurane followed by decapitation and the brains immediately dissected out, frozen on dry ice and stored at -80 °C until further processing for biochemical analyses. Another cohort of rats were anesthetized with isoflurane and perfused with saline followed by freshly prepared



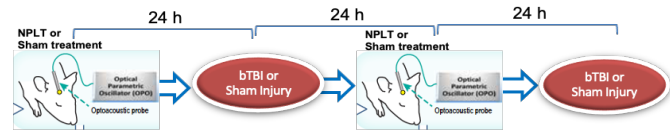
phosphate-buffered formaldehyde solution (pH 7.4). The brains were dissected and post-fixed in formaldehyde for 12-16 hours at room temperature, transferred to a phosphate buffered solution (PBS) and stored at 4 °C until ready for processing for histological staining (Figure 4).

During the current reporting period we have dissected and stored 32 rat brains for biochemical analyses and 16 rat brains for histopathological analyses.

Major activity related to Goal 3/ Major Task 4: NPLT treatment and blast TBI

Adult (2-month-old) male Sprague-Dawley rats were randomized to receive NPLT or no treatment and further randomized to receive two consecutive blast TBIs (48 hours apart) or sham-injury (Figure 5). NPLT treatments and bTBI were performed as described above in Major Task 1.

Figure 5. Major Task 4- NPLT treatment and blast TBI

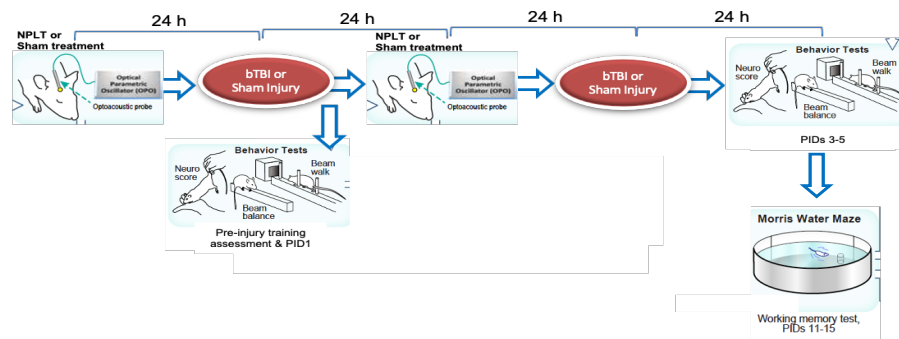


During the current reporting period we have initiated animal work- treatments (NPLT or Sham), injuries (bTBI or Sham injury) on 12 rats.

Major activity related to Goal 3/Task 5: Behavioral assessments

Behavioral assessment of neurological and cognitive function was performed as described above in Major Task 2 (Figure 6).

Figure 6. Major Task 5: Behavioral Assessments

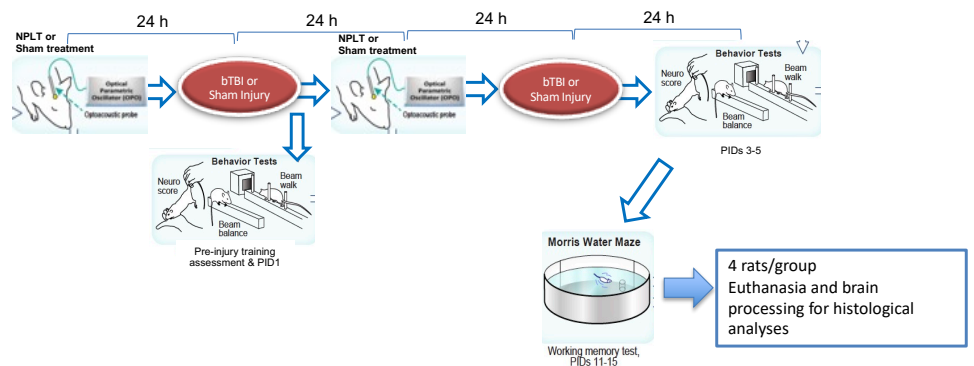


During the current reporting period we have initiated behavioral testing on a total of 12 rats.

Major activity related to Goal 3/Task 6: Biochemical and histological analyses

At the end of the water maze test rats were anesthetized with isoflurane and perfused with saline followed by freshly prepared phosphate-buffered formaldehyde solution (pH 7.4). The brains were dissected and post-fixed in formaldehyde for 12-16 hours at room temperature, transferred to a phosphate buffered solution (PBS) and stored at 4 °C until ready for processing for histological staining (Figure 7).

Figure 7.



During the current reporting period we have dissected and stored 12 rat brains for histopathological analyses to be performed as detailed in the proposal.

What opportunities for training and professional development has the project provided?

Nothing to Report

How were the results disseminated to communities of interest?

Nothing to Report

What do you plan to do during the next reporting period to accomplish the goals?

During the next annual reporting period, we plan to:

- Perform statistical analyses of behavioral data as detailed in Aim 1 – Goal 2/Task 2
- Perform histopathological staining and analyses as detailed in Aim 1 – Goal 2/Task 3
- Perform biochemical analyses as detailed in Aim 1 – Goal 2/Task 3
- Perform animal work- treatments (NPLT or Sham), injuries (bTBI or Sham injury) - as detailed in Aim 2 – Goal 2/Task 4
- Perform behavioral testing and statistical analyses as detailed in Aim 2 – Goal 3/Task 4
- Perform histopathological staining and analyses as detailed in Aim 2 – Goal 3/Task 5
- Perform biochemical analyses as detailed in Aim 2 – Goal 3/Task 6

4. IMPACT:

What was the impact on the development of the principal discipline(s) of the project?

Nothing to Report

What was the impact on other disciplines?

Nothing to Report

What was the impact on technology transfer?

Nothing to Report

What was the impact on society beyond science and technology?

Nothing to Report

5. CHANGES/PROBLEMS:

Changes in approach and reasons for change

Nothing to Report

Nothing to Report

Changes that had a significant impact on expenditures

Nothing to Report

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Significant changes in use or care of human subjects

Not Applicable

Significant changes in use or care of vertebrate animals

Nothing to Report

Significant changes in use of biohazards and/or select agents

Not Applicable

6. PRODUCTS:

- **Publications, conference papers, and presentations**

Journal publications.

Nothing to Report

Books or other non-periodical, one-time publications.

Nothing to Report

Other publications, conference papers and presentations.

Nothing to Report

- **Website(s) or other Internet site(s)**

Nothing to Report

- **Technologies or techniques**

Nothing to Report

- **Inventions, patent applications, and/or licenses**

Nothing to Report

- **Other Products**

Nothing to Report

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Name: Maria Micci
Project Role: Principal Investigator
ORCID ID: 0000-0001-6689-2994

Nearest person month worked: 2.4

Contribution to Project: Dr. Micci has planned, coordinated and directed the experimental work. She has prepared the technical report and communicated with the DoD.

Name: Stacy L. Sell
Project Role: Co-Investigator
UTMB ID: 047383

Nearest person month worked: 2.85

Contribution to Project: Dr. Sell has performed work related to the behavioral studies of the project.

Name: Helen Hellmich
Project Role: Co-Investigator
UTMB ID: 097512

Nearest person month worked: 2.85

Contribution to Project: Dr. Hellmich has performed work related to the molecular studies of the project.

Name: Rinat Esenaliev
Project Role: Co-Investigator
UTMB ID: 059206

Nearest person month worked: 0.6

Contribution to Project: Dr. Esenaliev has worked in the area of NPLT treatment oversight.

Name: Irene Petrov
Project Role: Co-Investigator
UTMB ID: 162553

Nearest person month worked: 0.6

Contribution to Project: Dr. I. Petrov has worked in the area of NPLT treatment administration
Funding Support:

Name: Yuriy Petrov
Project Role: Co-Investigator
UTMB ID: 160886

Nearest person month worked: 1.2

Contribution to Project: Dr. Y. Petrov has worked in the area of NPLT treatment administration.

Name: Nikita Gupta
Project Role: Graduate Student
UTMB ID: 254221
Nearest person month worked: 12
Contribution to Project: Ms. Gupta has performed work in the area of animal handling, bTBI/sham injury administration and behavioral testing.

Name: Kathia Johnson
Project Role: Research Associate
UTMB ID: 136690
Nearest person month worked: 6
Contribution to Project: Ms Johnson performed work in the areas of animal ordering, animal handling, behavioral studies, euthanasia and tissue collection and storage.

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

One active grant (Kleberg Foundation) for Dr. Micci has closed. See appendices for current other support for Dr. Micci. This change has not impacted Dr. Micci's effort on this project.

What other organizations were involved as partners?

Nothing to Report

8. SPECIAL REPORTING REQUIREMENTS

QUAD CHARTS:

Nano-pulsed Laser Optoacoustic Therapy for Pre-treatment and Post-treatment of Traumatic Brain Injury

DM180663; Year 1/Annual Report

W81XWH-19-1-0522

PI: Maria-Adelaide Micci

Org: University of Texas Medical Branch, Galveston

Award Amount: \$552,721.00 (\$350,000 direct cost)

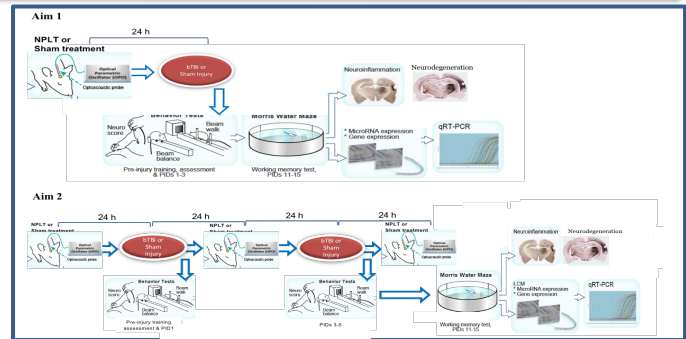


Study Aims)

- **Aim 1** will test whether NPLT can be used as preventive treatment before experimental TBI to reduce/delay neuropathology and cognitive impairment.
- **Aim 2** will test whether NPLT after each of multiple experimental TBIs will effectively mitigate neuropathology and cognitive impairments.

Approach

These aims will be accomplished by using an established rat model of blast TBI (bTBI). NPLT will be delivered to the intact rat head before bTBI (Aim 1) and after each bTBI in a repetitive injury paradigm (Aim 2). Two weeks after the last bTBI, neurocognitive outcome will be assessed, and rats will be euthanized for assessment of neuroinflammation and neurodegeneration in comparison to un-injured rats and sham-treated bTBI rats using ANOVA. We will focus our analyses on the cortex (frontal and parietal) and hippocampus, areas critically involved in learning, memory and executive functions, and among the earliest and most affected brain areas in TBI.



Accomplishment – During this reporting period we have performed animal work to assess the efficacy of NPLT for the treatment for repetitive bTBI (as detailed in Aim 1 of the proposal) and initiated histopathological analyses for Aim 1. We have initiated animal work for Aim 2.

Timeline and Cost

Activities	CY	19	20	21
ACURO Approval				
Aim 1-NPLT treatment and bTBI				
Aim 1- behavioral tests/biochemical and histological analyses				
Aim 2-NPLT treatment and bTBI				
Aim 2- behavioral tests/biochemical and histological analyses				
Estimated Budget (\$K)		\$53,500	\$196,500	\$100,000

Updated: October 28, 2020

Goals/Milestones

CY19 Goal – Preparing protocol of animal use for ACURO review

ACURO approval

CY20 Goals – Testing preventative NPLT efficacy for bTBI (Aim 1)

Complete NPLT treatment and blast TBI on 48 rats

Complete behavioral assessments

– **Testing NPLT efficacy for repetitive bTBI (Aim 2)**

Complete repetitive blast TBIs and NPLT treatments on 48 rats

Complete behavioral assessments

CY21 Goals – Testing preventative NPLT efficacy for bTBI (Aim 1)

Complete histological analyses

Complete biochemical analyses

– **Testing NPLT efficacy for repetitive bTBI (Aim 2)**

Complete histological analyses

Complete biochemical analyses

Comments/Challenges/Issues/Concerns- Nothing to Report.

Budget Expenditure to Date

Projected Expenditure: \$210,000; Actual Expenditure: \$207,000

9. APPENDICES

Other Support

Micci, Maria

Current

W81XWH1910522 Micci (PI) 09/30/19-03/31/21 2.04 cal mths

Dept of Defense

"Nano-Pulsed Laser Optoacoustic Therapy for Pretreatment and Post-Treatment of Traumatic Brain Injury"

Goal: To demonstrate in a rodent model that a unique, non-invasive, nanopulsed laser optoacoustic therapy (NPLT) is a promising pre-treatment for military personnel at high risk of combat-related TBI and a promising treatment after combat-related TBI, with the goal of limiting onset and progression of neuropathology and cognitive impairment.

Aims: 1) To test whether NPLT can be used as a preventive treatment before experimental TBI to reduce/delay neuropathology and cognitive impairment; 2) To test whether NPLT after each of multiple experimental TBIs will effectively mitigate neuropathology and cognitive impairments.

Role: Principal Investigator

Contact: Kevin R. Moore, 820 Chandler St., Fort Detrick, MD 21702, 301-619-7101,
kevin.r.moore88.civ@mail.mil

Overlap: None

R56 AG063405 Tagliatela;Micci (PI) 07/15/19-06/30/21 3.60 cal mths

National Institutes of Health

"Mechanisms of Resilience to Alzheimer's Disease Neuropathology"

Goal: To identify previously unappreciated molecular/cellular mechanisms linking preserved numbers of neural stem cells in the hippocampus to cognitive resilience in Alzheimer's disease, thereby improving patients' health and decreasing costs associated with care.

Aims: 1) To test the hypothesis that NSC-derived exosomes reduce synaptic susceptibility to amyloid oligomers binding and its functional consequences; 2) To characterize microRNAs uniquely present in NSC-exosomes responsible for these effects; 3) To document the translational value of this novel mechanism employing human NSC and neurons derived from iPSCs.

Role: Principal Investigator

Contact: Bradley C. Wise, 7201 Wisconsin Ave, Bethesda, MD 20814, 301-496-9350, wiseb@nia.nih.gov

Overlap: None

**R01 AG069433 Tagliatela (PI) 08/01/20-04/30/25 3.60 cal mths

National Institutes of Health

"Promoting Brain Resilience to Alzheimer's Neuropathology"

Goal: The overall objective in this application, is to evaluate the link between NSC (and their released exosomes) and increased synaptic resilience to the toxic actions of tau oligomers as a function of aging, the strongest AD risk factor.

Aims: To obtain the overall objective, we will pursue three specific aims that will evaluate the efficacy of NSC-exo in promoting synaptic resilience to Tau oligomers (Aim 1), determine the involved miRNA cargoes and their impact on key synaptic proteins (Aim 2) and evaluate the impact of aging on such protective mechanisms as a function of decreasing numbers of resident NSC and their released exosomes (Aim 3).

Role: Principal Investigator

Contact: Bradley C. Wise; Email: wiseb@nia.nih.gov Phone: 301-496-9350

Overlap: None

Ended

CON26297, Kleberg Foundation, ended 2/28/21

** New award