

AD_____

Award Number: DAMD17-01-1-0318

TITLE: Immunotherapeutic Strategies in Breast Cancer: Preclinical And Clinical Trials

PRINCIPAL INVESTIGATOR: Sandra J. Gendler, Ph.D.

CONTRACTING ORGANIZATION: Mayo Clinic and Foundation
Scottsdale, AZ 85259

REPORT DATE: September 2006

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel 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 (DD-MM-YYYY) 01-09-2006		2. REPORT TYPE Final		3. DATES COVERED (From - To) 15 AUG 2005 - 14 AUG 2006	
4. TITLE AND SUBTITLE Immunotherapeutic Strategies in Breast Cancer: Preclinical And Clinical Trials				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER DAMD17-01-1-0318	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Sandra J. Gendler, Ph.D. E-Mail: gendler.sandra@mayo.edu				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Mayo Clinic and Foundation Scottsdale, AZ 85259				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel 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: This project is focused on novel tumor vaccines directed at MUC1 and other tumor antigens. Our specific aims are: 1)To assess the effectiveness of vaccines against MUC1 and other tumor antigens in the prevention and treatment of spontaneous breast carcinomas in mice; 2)To translate an effective vaccine strategy into a phase I clinical trial in patients with undetectable disease following standard therapy. The model of spontaneous mammary cancer is the MUC1-expressing polyoma middle T antigen mice (MMT). We have tested five vaccines in the preclinical mouse model and all elicited a strong immune response. The vaccine using MUC1 class I binding peptides prevented MUC1-expressing tumor growth. We have designed the Phase I clinical trial using a peptide vaccine comprised of MUC1 and HER-2/neu MHC class I peptides and HER-2/neu MHC class II peptide with unmethylated CpG oligodeoxynucleotides and GM-CSF as adjuvants. The clinical trial has been unanimously approved by the Mayo Institutional Review Board (IRB 582-05) following receipt of FDA approval (BB-IND 12155). The peptides have been synthesized and vialled. It is a phase I trial testing MUC1 and HER-2/neu class I and class II peptides with CpG ODN and GM-CSF adjuvants in breast cancer patients free of disease. The amended clinical trial documents, which have been accepted by Colonel Brosch of the HSRRB on July 24, 2006, have been submitted to the Mayo IRB for approval. Approval should be forthcoming shortly. The approval notice and the documents reviewed and approved by the Mayo IRB will then be resubmitted to the HSRRB in order to obtain an Approval Memorandum prior to opening the clinical trial.					
15. SUBJECT TERMS Immunotherapy, vaccine, MUC1, mucin, mouse model, tolerance					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			USAMRMC
U	U	U	UU	63	19b. TELEPHONE NUMBER (include area code)

Table of Contents

Cover.....	
SF 298.....	2
Table of Contents.....	3
Introduction.....	4
Body.....	4
Key Research Accomplishments.....	6
Reportable Outcomes.....	6
Conclusions.....	7
Appendices.....	7

INTRODUCTION

This project is focused on the development of novel tumor vaccines directed at MUC1, a transmembrane mucin that is aberrantly expressed in cancer. MUC1 is expressed on greater than 90% of breast cancers and often elicits cellular and humoral immune responses in humans. However, these responses are not sufficiently strong to eradicate tumors. In tumors, there is strong over expression of MUC1 on tumor cells and in circulation, expression is no longer restricted to the apical domain of cells, and glycosylation is altered, revealing immunodominant tumor-specific peptide sequences. MUC1 is a candidate for novel immunotherapy strategies to strongly activate the immune system to eradicate tumors expressing MUC1 epitopes.

In our preclinical studies we have utilized mice that develop spontaneous mammary gland cancer that express MUC1. MUC1 transgenic mice (MUC1.Tg) were bred with mice carrying the MMTV-driven polyoma middle T antigen (MT) to create MMT mice. Mice transgenic for this protein develop B and T cell tolerance and are refractory to immunization with the protein encoded by the transgene. All mice are congenic on the C57BL/6 background to eliminate strain-specific modifier effects. In the MMT mice, mammary gland tumors are induced by the action of a potent tyrosine kinase activity associated with the polyoma virus middle T antigen driven by the mouse mammary tumor virus long terminal repeat (MMTV) [2]. Middle T specifically associates with and activates the tyrosine kinase activity of a number of c-src family members, eliciting tumors when a threshold level of gene product has been attained. This promoter is transcriptionally active throughout all stages of mammary gland development and results in widespread transformation of the mammary epithelium and the rapid production of multifocal mammary adenocarcinomas in 100% of the female mice. The MMT mouse appears to be an appropriate model for human cancer and allows us to study the effects of self-tolerance, immunity and auto-immunity to MUC1 as mammary tumors develop spontaneously.

The **hypothesis** of our study is that enhancing MUC1-specific immunity will result in anti-tumor immunity. We propose to develop an optimal cancer vaccine using MUC1 peptides or MUC1-expressing tumors presented by DCs as immunogen. The most successful therapies will be tested in a phase I clinical trial. An additional hypothesis is that immune tolerance within the tumor microenvironment can be overcome by MUC1-based novel immunotherapeutic strategies.

Our **specific aims** are: **1)** to assess the effectiveness of vaccine formulations against MUC1 in the prevention and treatment of spontaneous breast carcinomas in mice and **2)** to translate an effective vaccine strategy into a Phase I clinical trial in patients with minimal residual disease.

The clinical trial protocol and the patient consent form for aim 2 are included in this annual report. Both have received FDA (IND # 12155), Mayo IRB (IRB 782-05), and HSRRB approval (A-10856). These documents were formally submitted on August 30, 2006, for final approval from the Mayo IRB. This approval process is underway. Following Mayo IRB approval, the documents reviewed by the Mayo IRB will be re-submitted to the HSRRB for the Approval Memorandum prior to opening the clinical trial.

RESULTS (BODY)

Specific Aim 1: To assess the effectiveness of vaccine formulations against MUC1 and other tumor antigens in the prevention and treatment of spontaneous breast carcinomas in mice.

Our preclinical studies were completed at the end of year three and the papers describing the results were included in the progress report last year.

Specific Aim 2: To translate the most effective vaccine strategies into phase I clinical trials in patients with high and low tumor burden.

Description of Regulatory Status of the Clinical Trial The clinical trial entitled “MUC1/HER-2/neu Peptide Based Immunotherapeutic Vaccines for Breast Adenocarcinomas” and the Patient Consent Form are included in the appendix. The proposal for the clinical trial has been approved by the FDA (**IND#12155**) and the Mayo Institutional Review Board (**IRB 782-05**). Colonel Laura R. Brosch (USAMRMC) accepted the amendments (**A-10856**) made to the clinical trial and patient consent form on July 24, 2006; these amended documents have been submitted to the Mayo IRB on August 30, 2006 for their approval, which is pending. Upon their approval, the letter of approval and the packet that was reviewed and approved will be sent to Dr. Inese Z. Beitins, Human Subjects Protection Scientist, AMDEX Corporation, as requested.

Patient Population

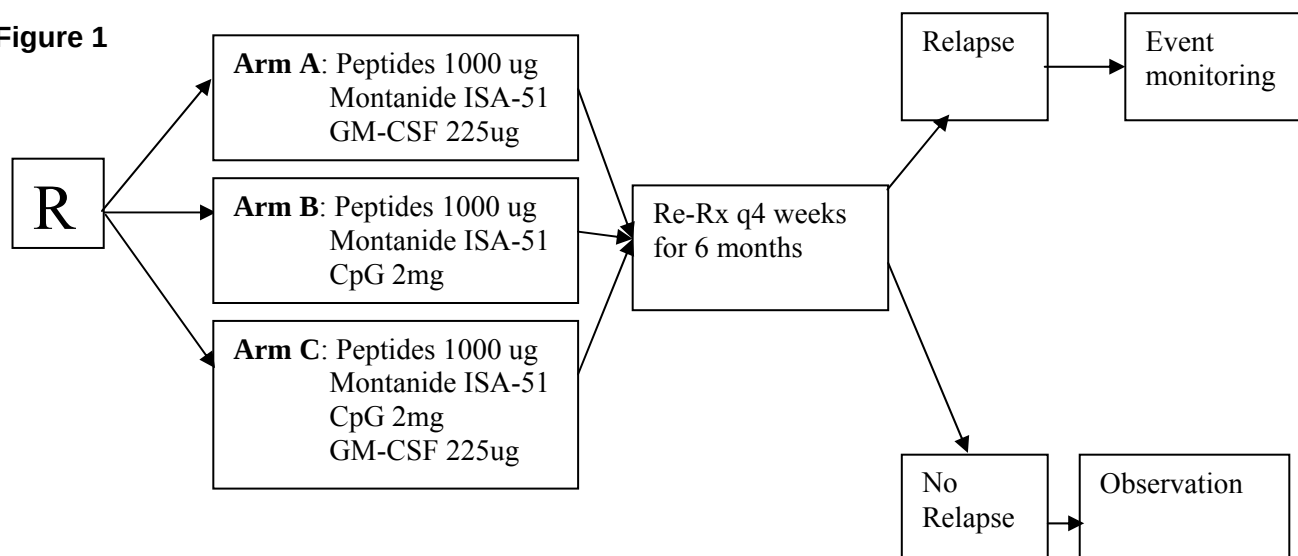
Breast cancer is the most common type of tumor seen at Mayo Clinic. Considering all three sites, a total of 1,736 new breast cancer patients were seen in 2003 including 1,084 at the Rochester campus, 228 at the Jacksonville campus and 424 at the Scottsdale campus. We have access to all the patients with breast cancer seen at all three Mayo campuses. In addition to a large clinical practice, the Mayo Clinic records system allows review of patient data going back almost one century. We also have data from breast cancer patients entered on prospective clinical trials over the last 30 years. Since 2000 we have prospectively recruited 877 women to a breast cancer patient registry in which a lifestyle and family history questionnaire is obtained. Of these 877 patients, 804 (92%) have provided a blood sample for DNA extraction and 364 patients (42%) have paraffin-embedded tissue available. We have compiled a list of patients that would be eligible for this clinical trial. Once we have completed the review process, these patients will be contacted regarding their interest in participating in the trial. Interest is very high, as immunotherapy has been shown to be a non-toxic therapy.

The trial will test MUC1 class I peptide (STAPPVHNV), HER-2/neu class I peptide (ILHNGAYSL) and HER-2/neu class II peptide (KVPIKWMALESIL) (1000 µg of each peptide) delivered in Montanide ISA-51 and compare GM-CSF with unmethylated CpG oligodeoxynucleotides as immune adjuvants. Few vaccines have been tested in the optimal setting of minimal residual disease. CpG unmethylated oligodeoxynucleotides are a novel adjuvant that promote strong, antigen-specific T cell responses and help to overcome immune tolerance.

The peptides have been synthesized and vialled by Clinalfa (Merck Biosciences AG) and are being stored at the Mayo Clinic Comprehensive Cancer Center in Rochester. The peptides are certified for use in human studies and they fully comply with the international ethical and scientific quality standards, as stated in “ICH Guideline E6: Good Clinical Practice”. The “Certificate for Analysis” for each peptide is included in the appendix.

The schema for the clinical trial is shown (Fig. 1).

Figure 1



KEY RESEARCH ACCOMPLISHMENTS

- The preclinical research was completed and described in the annual reports for years 3 and 4.

REPORTABLE OUTCOMES

- The Clinical Trial and Patient Consent are included in the appendix. They have received FDA (IND # 12155) and Mayo IRB (IRB 782-05) approval. Colonel Brosch has accepted the amendments to the documents secondary to the recommendations of the Subcommittee of the HSRRB (e-mail dated July 24, 2006 from Dr. Inese Beitins, Human Subjects Protection Scientist).
- The revised clinical trial protocol and patient consent were submitted to the Mayo IRB on August 30, 2006 for final approval.

Time Table of Protocol Development

- Clinical protocol concept approved by Mayo Clinic Cancer Center 12-11-03
- Completed Mayo Clinic Cancer Center Peer Review process 5-4-04
- List of recommendations by FDA (pre IND conference) 4-21-04
- Peptides synthesized and vialled by ClinAlfa[®] for use in this clinical trial:
 1. Her-2/neu (435-443) 7-16-04
 2. Her-2/neu (883-899) 8-6-04
 3. MUC1(950-958) 11-10-04
- Completion of IND documentation and submission to FDA on December 17, 2004.
- FDA approval (IND # 12155)
- Mayo IRB approval April 22, 2005 (IRB 782-05)
- Submission to DOD HSRRB on May 11, 2005
- Submission to FDA of the revised 1572 and Investigator's Brochure on September 15, 2005
- Submission to Mayo IRB of amendment, which excludes prisoners from the study population and reduces the number of personnel involved in the study (September 12, 2005)
- Submission of revision to HSRRB on February 10, 2006 (response to request for revisions from 14 December 2005 HSRRB meeting)
- Submission of revision to HSRRB on May 18, 2006
- Acceptance of the amendments by Colonel Laura R. Brosch, USAMRMC
- Submission of final documents to the Mayo IRB August 30, 2006

CONCLUSIONS

The past year has been spent revising the clinical protocol and patient consent and receiving approval from the HSRRB. Permission was granted (on July 24, 2006) to submit the amended documents to our Mayo IRB for final approval. These documents were submitted August 30, 2006; approval is pending. Following the Mayo IRB approval, the letter of approval and the packet that was reviewed and approved will be sent to Dr. Inese Z. Beitins, Human Subjects Protection Scientist, AMDEX Corporation, for submission to the HSRRB.

We anticipate that the trial will open in late 2006. We presently have a list of patients who would be eligible for this trial. We anticipate that there will be rapid accrual.

Future Studies

The clinical trial will open shortly. We will enroll the patients and perform the immunologic assays once final USAMRMC approval has been received.

Appendices

Packet Submitted to Mayo IRB for final approval (August 30, 2006)

- Protocol Modification Request Form (IRB 782-05)
- Clinical Trial MC0338 – MUC1/HER-2/neu Peptide Based Immunotherapeutic Vaccines for Breast Adenocarcinomas
- Patient Consent Form

Protocol Modification Request Form

Mayo Foundation Institutional Review Board (IRB)

PLEASE NOTE: This form must accompany ALL protocol modification requests. If consent form changes are required, an electronic copy of the revised consent form (with revisions indicated by track changes function) **MUST** be provided to IRB.

This form cannot be submitted electronically.

If hard copy documentation will be included with the request, please **print** this completed form, attach the supporting documentation, and mail ALL the materials together in hard copy to IRB, 201 Bldg, 4-60. **It is extremely important that all materials (i.e. this form, revised consent, supporting materials) be sent together and that duplicate copies of materials are NOT sent to the IRB.**

Today's date 6/21/06

1. IRB Number of study: 782-05
2. Title: MC0338; MUC1/HER-2/neu Peptide-Based Immunotherapeutic Vaccines for Breast Adenocarcinomas
3. Principal Investigator: S.N.Markovic,MD.,Ph.D. Pager # 4-6188
4. Study Coordinator(s): Jane Milburn Pager # 6-8826 Fax # 4-5280
5. Mark one of the following: ☐ Investigator-initiated changes ☒ Sponsor-initiated changes

Amendment name and number (if any):	Communication prior to activation	Date of amendment (if applicable):
-------------------------------------	--	------------------------------------

6. Is this study open to the enrollment of new participants? Yes ☐ No ☒
7. Are any participants still receiving study treatment? Yes ☐ No ☒
8. a. Is this study also being done at another Mayo site under a separate IRB number? Yes ☐ No ☒
- b. If yes, indicate IRB number of the identical study/studies here: _____

**Reminder: Modification requests for identical studies with different IRB #'s must be reviewed by the IRB at the same time.*

Nature of Requested Modifications: please check all applicable categories, and describe each change concisely and specifically in the middle column of the table below. For example, "addition of a liver biopsy on day 3" or "increase frequency of [drug] dosing schedule from once weekly to twice weekly".

In addition, the justification for each requested modification must be specified in the corresponding column.

Do not write "See attached summary" as a replacement for either the listing of modifications or justifications. If this form is incomplete in any way, it may be returned to you for completion.

☒	Change in study design or procedures	<u>List of Modifications</u> Page 13 (Section 2.2): The secondary Goal has been revised to read as follows: To describe the impact of immunization on clinical outcomes in patients with MUC1 positive breast cancer. Clinical outcomes of interest will include: (1) disease-free survival defined	<u>Justification for each requested change</u> At the request of the Department of Defense, one of the sponsors of the study.
-------------------------------------	--------------------------------------	---	---

		as the time from registration to the documentation of a first failure where a failure is the recurrence (REC) of breast cancer or a diagnosis of a second primary cancer (NEWP); and (2) overall survival defined as the time from registration to death due to any cause. Page 18 (Section 7.4): The first sentence of the third paragraph was removed; and it had read: The risks to the patients taking part on this study are minimal. Page 28 (section 15.52): The Known Potential Toxicities paragraph was updated to be consistent with the consent form. That paragraph now reads: Fever, chills, asthenia, malaise, numbness, increased sensitivity to touch, loss of balance, dizziness, rash, peripheral edema, dyspnea, headache, pericardial effusion, bone pain, arthralgia, nausea, vomiting, loss of appetite, developing or worsening of kidney or liver problems, difficulty breathing, shortness of breath, redness of the skin, facial flushing, rapid or irregular heartbeat or other heart problems, low blood pressure, myalgia, and serious allergic reactions such as a severe asthma attack. Page 32 (Section 16.446) The section has been added in its entirety and reads as follows: It should be noted that representatives of the U.S. Army Medical Research and Materiel Command are eligible to review research records as a part of their responsibility to protect human subjects in research.	At the request of the Department of Defense, one of the sponsors of the study. At the request of the Department of Defense, one of the sponsors of the study, At the request of the Department of Defense, one of the sponsors of the study.
--	--	--	---

☒	Revisions to consent form <i>Revised consent form must be submitted electronically to the IRB as indicated at the top of the form.</i>	<u>List of Modifications</u> The attached consent form has been revised (as indicated by bold and strikethrough text).	<u>Justification for each requested change</u> At the request of the Department of Defense, one of the sponsors of the study.
-------------------------------------	---	--	---

The current consent form template is accessible [<here>](#).

☐	Addition of study personnel (please include <u>full name</u> including middle initial, and indicate <u>role</u> in the study)	Please check this box if added personnel are <u>replacing</u> others being removed, and clarify all replacements being made, including role in the study: ☐	
☐	Removal of study personnel (please include <u>full name</u> including middle initial, and indicate <u>role</u> in the study)		
☐	Other changes (editorial, administrative, funding, corrections/changes, etc)	<u>List of Modifications</u>	<u>Justification for each requested change</u>

If the protocol involves use of the GCRC, a copy of this submission must be sent to GCRC, Domitilla 5.

IF THE PROPOSED MODIFICATIONS NECESSITATE A REVISION TO THE WRITTEN PROTOCOL IN ANY WAY, A COPY OF THE PROTOCOL (INCORPORATING THE APPROPRIATE CHANGES) IS REQUIRED FOR IRB REVIEW.

Principal Investigator's Signature

Date

If you have questions, please refer to the online "Manual for Investigators Conducting Research Involving Humans" (<http://researchweb.mayo.edu/irbmanual/>), or call the IRB Office at 4-2329.

Mayo Clinic Cancer Center

**MUC1/HER-2/neu Peptide Based Immunotherapeutic Vaccines
for Breast Adenocarcinomas**

Principal Investigators/Study Chairs: Svetomir Markovic, M.D., Ph.D. *⁺
Mayo Clinic Cancer Center
200 First Street, SW
Rochester, MN 55905
507/284-2511
507/284-5280 (FAX)

Sandra J. Gendler, Ph.D. ✓
Mayo Clinic Scottsdale
13400 E. Shea Boulevard
Scottsdale, AZ 85255
480/301-7062
480/301-7017 (FAX)

Study Co-chairs: James N. Ingle, M.D (Mayo Clinic, Rochester)
Pinku Mukherjee, Ph. D (Mayo Clinic, Scottsdale) ✓
Tom Fitch, M.D (Mayo Clinic, Scottsdale)
Barbara Pockaj, M.D (Mayo Clinic, Scottsdale)
Edith A. Perez, M.D. (Mayo Clinic, Jacksonville)

Statistician: Vera J. Suman, Ph.D. ✓

* Investigator having primary responsibility for this protocol

⁺ IND sponsor (IND# 12155)

✓ Study contributor(s) not responsible for patient care.

Document History

(effective date)

IRB approved draft version:

April 22, 2005

Revised draft version:

February 3, 2006

Activation version:

Pending approvals

Protocol Resources

Questions:	Contact Name:
Review all unanticipated problems involving risk to volunteers or others, serious adverse events and all volunteer deaths associated with the protocol and provide an unbiased written report of the event	Ravi D. Rao, M.B.B.S. Medical Monitor Phone: 507-266-5365 E-mail: rao.ravi@mayo.edu
Patient eligibility*, test schedule, treatment delays/interruptions/adjustments, dose modifications, adverse events, forms completion	Carol Leonard Quality Control Specialist Phone: 507-284-3121 Fax: 507-284-1902 E-mail: leonard@mayo.edu
Drug administration, infusion pumps, nursing guidelines	Lisa Carpenter, RN Mayo Clinic Cancer Center Nurse Phone: 507-538-2958 E-mail: carpenter.lisa@mayo.edu
Clinical data submission and record maintenance	Kathleen Liffbrig Clinical Research Associate Phone: 507-266-0347 E-mail: Liffbrig.kathleen@mayo.edu
Protocol document, consent form, Regulatory issues	Jane M. Milburn, BA, MBA Protocol Development Coordinator Phone: 507-266-0743 Fax: 507-284-5280 E-mail: milburn@mayo.edu
Technical problems with electronic form entry	Vicki Bryhn Protocol Administration Specialist Phone: 507-266-5350 Fax: 507-284-1902 E-mail: bryhn@mayo.edu

Index

Schema

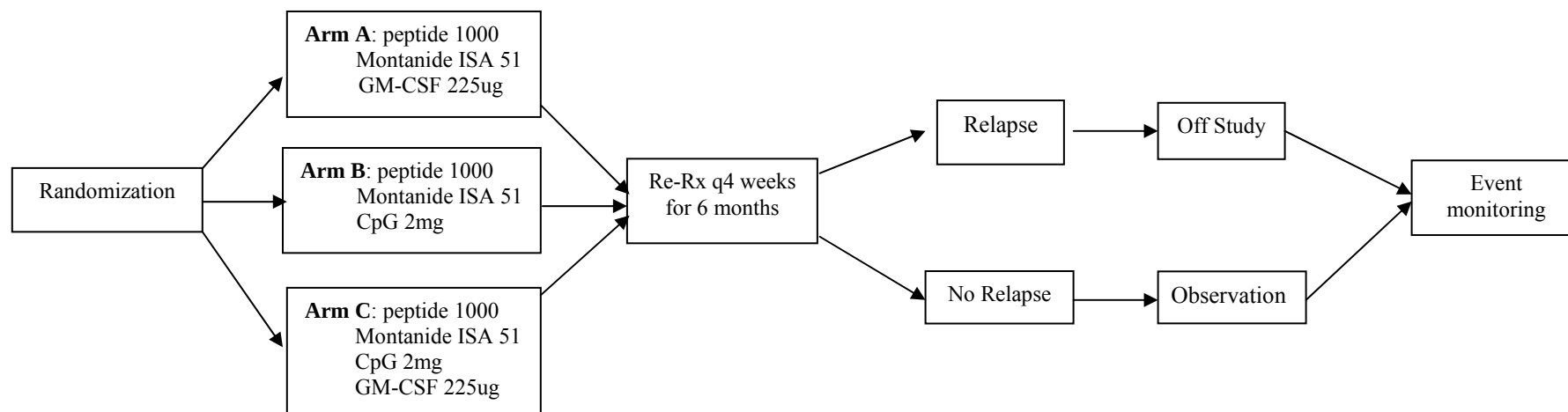
- 1.0 Background
- 2.0 Goals
- 3.0 Patient Eligibility
- 4.0 Test Schedule
- 5.0 Grouping Factors
- 6.0 Registration/Randomization Procedures
- 7.0 Protocol Treatment
- 8.0 Dosage Modification Based on Adverse Events
- 9.0 Ancillary Treatment/Supportive Care
- 10.0 Adverse Event (AE) Reporting and Monitoring
- 11.0 Treatment Evaluation
- 12.0 Descriptive Factors
- 13.0 Treatment/Follow-up Decision at Evaluation of Patient
- 14.0 Correlative/Translational Studies
- 15.0 Drug Information
- 16.0 Statistical Considerations and Methodology
- 17.0 Pathology Considerations
- 18.0 Data Collection Procedures
- 19.0 Budget Considerations
- 20.0 References

Appendix I ECOG Performance Status Scale

Appendix II Injection Site Record

Consent Form

Schema



1.0 Background

- 1.1 Breast cancer is diagnosed in 200,000 individuals in the United States annually and contributes to approximately 40,000 deaths each year. For tumors confined to the breast, surgical removal provides a good prognosis. However, primary tumor that metastasizes to distant sites, such as lymph nodes, lungs, liver and brain, correlates with a poor prognosis. Patients with advanced stage breast cancer are at high risk of relapse. Complications from metastatic disease are the leading causes of cancer-related deaths. Novel adjuvant strategies, such as breast cancer specific vaccines, are being considered as a clinical intervention that may reduce the chance of recurrence.

In recent years there has been great interest in the development of these cancer vaccines, which are designed to immunize individuals to antigens present on tumors. Cancer vaccines are a non-toxic therapy, which have been shown in several melanoma trials to have the potential of controlling disease and prolonging survival because tumors can be surgically removed and there is often a long period of time before the tumor recurs at metastatic sites, cancer vaccines have been proposed as an optimal therapy that could prolong the time to recurrence. This optimal opportunity of immunization in the situation of minimal residual disease has rarely been tested, however, as most vaccines have been given to patients with large tumor burden after the failure of standard therapies in Phase I and Phase II trials. Recently, several groups have addressed the use of adjuvant immunotherapy following complete surgical resection [1]. Data from these studies are not yet complete.

- 1.2 The past two decades in tumor immunology have led to the discovery of specific tumor antigens that have been shown in preclinical studies to elicit tumor-specific immunity and establish long term memory without autoimmunity. For breast cancer, vaccines composed of epitopes derived of MUC1, HER-2/neu, MAGE3, CEA have been studied and shown to be immunogenic without causing autoimmunity [2-5].
- 1.3 It is now clear that tumor antigens are presented in the context of specific class I and Class II HLA molecules. Class I presentation, in the presence of appropriate co-stimulation, is thought to stimulate a cytolytic CD8⁺ T cell response, while antigen presentation in the context of Class II molecules stimulates a CD4⁺ helper T cell response [6].
- 1.4 One approach for the development of a cancer vaccine is the use of tumor associated synthetic antigens for immunologic priming. Because specific peptides are ubiquitous in tumors of the same histologic type, identical peptide vaccines may be employed in allogeneic hosts bearing the same tumor histology. Additionally, the use of single peptides for immunization limits the potential induction of undesired autoimmunity [7-9]. Recent developments in the use of soluble MHC Class I/peptide tetramers and elispot technology have enabled rapid characterization of epitope-specific CTL responses [10, 11]. In addition to being well-explored and understood, many of these antigens are shared tumor antigens. Vaccines that are composed of these antigens can be developed for use in a large number of patients. The primary limitations to peptide based vaccine strategies are haplotype restriction, potential for degradation, and uncertainty regarding which peptides, used alone or in combination, are the most immunogenic [12, 13]. This study is designed to test these uncertainties.
- 1.5 One attractive and broadly applicable target for immunotherapeutic strategies is the MUC1 tumor antigen. MUC1, a cell-associated mucin, is expressed on the cell surface of many epithelial malignancies as well as by hematological malignancies [14-17]. These include multiple myeloma (92%) and acute myelogenous leukemia (67%) [18]. Greater than 90% of breast carcinomas express MUC1; high levels are also found in adenocarcinomas originating from most tissues [14, 16]. MUC1 expression is greatly up-regulated on tumors (reviewed in

Gendler [19]). Expression on tumors is no longer apical, but it is found all around the cell surface and in the cytoplasm. In addition, glycosylation on tumor-synthesized MUC1 is aberrant, with greater exposure of the peptide core than is found in normal tissues. MUC1 has long been an interesting target molecule for immunotherapeutic strategies, given its high level and ubiquitous expression. Patients with tumors, especially with breast, pancreas and ovarian tumors, have exhibited immune responses to MUC1 with the presence of antibodies and T cells specific for MUC1 detected in about 10% of individuals. An HLA unrestricted T cell response among cancer patients has also been described [20-23]. There is increasing evidence from murine and human studies that MHC-restricted T cells can be induced in mice and humans after immunization with the MUC1 peptide or MUC1 antigenic epitopes [24-32]. Importantly, there have been reports of two HLA-A2 binding peptides derived from the MUC1 protein [33]. One of the peptides is from the tandem repeat sequence of MUC1 and the second peptide is from the signal sequence. MUC1-specific cytotoxic T cells (CTLs) have been induced in T cells from healthy donors following *in vitro* immunization using peptide-pulsed dendritic cells. MUC1-specific CTLs have also been induced *in vivo* after vaccination of breast and ovarian cancer patients with peptide-pulsed DCs [18].

- 1.6 A second candidate for peptide-based immunotherapy is HER-2/neu, the gene product of the *erbB2/neu* protooncogene. HER-2/neu is overexpressed in approximately 30% of breast cancer patients. HER-2/neu is also expressed by multiple types of tumors, including ovarian, lung, colon, pancreas and gastric tumors [34-36]. HER-2/neu has particular relevance, as it is expressed at high levels in early *in situ* lesions in breast carcinoma [37]. Thus, it is a target for early disease. Immunologic responses to HER-2/neu have been detected in a minority of patients with advanced stage breast and ovarian cancer, including antibodies, T helper and CD8 responses [38, 39]. Several HLA-class I binding peptides have been previously identified. A novel HLA-A2.1 binding peptide from the HER-2/neu extracellular domain [HER-2(9₄₃₅)] was recently identified [40]. This peptide (ILHNGAYSL) bound to HLA-A2.1 with intermediate affinity (IC₅₀ 74.6 nM). The HER-2(9₄₃₅) epitope was tested using an *in vitro* immunization protocol and found to elicit CTLs that killed peptide-sensitized target cells. The CTLs elicited also recognized the HER-2/neu antigens, as it specifically killed tumor cells expressing the HLA-A2.1 and HER-2/neu antigens (see below in preliminary data). Furthermore, recognition of the tumor cell targets was significantly inhibited by unlabeled (cold) targets pulsed with HER-2(9₄₃₅), but not by unlabeled targets either unpulsed or pulsed with a control HLA-A2.1 binding peptide (see below). Thus, the CTLs induced by HER-2(9₄₃₅) are antigen specific.

A potential limiting factor for peptide based immunotherapy is related to a defined antigenic repertoire which is HLA restricted. This factor, inherent to all peptide-based approaches, restricts patient access. Additionally, because individual peptides only have the potential to induce epitope-specific CTL, the vast majority of potential tumor antigens are not targeted. In this setting, tumor down regulation of individual antigens or HLA epitopes promotes immune evasion. Recent evidence, however, suggests that this problem of epitope restriction may not be as physiologically important as was previously postulated. Specifically, it has now been clearly demonstrated that a T cell response induced against one epitope can stimulate CTL response to other target epitopes through a mechanism termed epitope spreading [3, 41, 42]. Using an experimental autoimmune encephalitis model, Vanderlugt et al. have demonstrated that disease progression is associated with the development of epitope-specific helper T cells, which are distinct from those initiating the disease. Transfer of secondary CD4⁺ cells to naïve mice induces the disease phenotype and the disease is abrogated by blocking the secondary T cell response even though the primary T cell response remains intact [43, 44]. Disis demonstrated epitope spreading in 84% of patients vaccinated with HER-2/neu peptides, reflecting the initiation of an endogenous immune response. The immunity persisted after active immunizations ended [3]. These data suggest that peptide based approaches to cancer immunotherapy may indirectly stimulate multiple tumor reactive CTL against minor antigens in

the presence of residual tumor. Based on this concept, the current study is designed as a therapeutic approach, with peptide epitope selection designed to enhance the number of potential candidates.

In addition to class I epitopes, immunogenic HLA-DR restricted class II epitopes have been defined for HER-2/neu. CD4⁺ helper T lymphocytes (T_H) responses play an essential role in immunologically mediated anti-tumor immunity [45]. T_H lymphocytes provide CTLs with growth-stimulating cytokines, prime/activate DCs to effectively present antigen to naive CTL precursors [46-48] and they are important in the development of immune memory [49-51]. The development of IgG antibodies to HER-2/neu and the identification of CD4⁺ T cells that secrete cytokines in response to HER-2/neu peptides or recombinant HER-2/neu protein suggest responses to helper T cells [52-57]. A promiscuous MHC class II T_H epitope has been identified for the HER-2/neu antigen (HER-2₈₈₃). T cell responses are restricted by HLA-DR1, HLA-DR4, HLA-DR52, and HLA-DR53 [58]. Peptide-induced T cells were effective in recognizing naturally processed HER-2/neu protein. The peptide HER-2₈₈₃, (KVPIKWMALESILRRRF), which was selected by computer algorithm, was tested for its capacity to stimulate CD4⁺ T cells isolated from four healthy, MHC-typed individuals (DR1/11, DR1/13, DR4/15, DR7/17) in primary *in vitro* culture using peptide pulsed autologous DCs. T cells that proliferated were found to react with peptide and recombinant HER-2/neu intracellular domain protein presented by autologous DCs (see below). These results, showing reactivity with recombinant protein, suggest that HER-2₈₈₃ is naturally processed, as the peptide stimulated T cells react with DCs primed with recombinant protein. Clearly, HER-2₈₈₃ is a naturally processed peptide epitope and is promiscuous for multiple HLA-DR epitopes, making it an ideal candidate for therapeutic applications.

- 1.7 Because of the expression of MUC1 and HER-2/neu in multiple cancers, the development of this peptide-based immunotherapy can potentially impact the treatment of multiple disease entities, not only adenocarcinomas but hematopoietic malignancies as well. There is considerable interest in the use of the MUC1 peptide vaccination for treatment of multiple myeloma following transplant when there is minimal residual disease prior to remission.

- 1.8 **GM-CSF**
Granulocyte-macrophage colony stimulating factor (GM-CSF) is a commercially available cytokine currently used in patients undergoing chemotherapy to shorten the duration of post-chemotherapy neutropenia. Recently published evidence also suggests that GM-CSF may play a role as an immune adjuvant [59, 60]. The following observations illustrate the mechanisms by which GM-CSF can potentiate the immunogenicity of an antigen: 1) GM-CSF is a key mediator of dendritic cell (DC) maturation and function [61]; 2) GM-CSF increases surface expression of class I and II MHC molecules as well as co-stimulatory molecules of dendritic cells *in vitro* [61]; 3) GM-CSF enhances antibody responses to known immunogens *in vivo* [62]; 4) tumor cells transfected with genes encoding/expressing GM-CSF are able to induce long lasting, specific anti-tumor immune responses *in vivo* [63]; 5) GM-CSF encapsulated in biodegradable microspheres mixed with whole tumor cells resulted in systemic anti-tumor immune responses comparable to those of GM-CSF transfected tumor cells [64]. Therefore, addition of GM-CSF to an oligopeptide antigen may substantially enhance its immunogenicity.

In an attempt to optimally enhance the immunogenicity of the peptides we will deliver the antigens and GM-CSF emulsified in incomplete Freund's adjuvant (IFA, Montanide ISA-51). This delivery mechanism should be comparable to a previously demonstrated delivery mechanism utilizing GM-CSF suspended in microspheres and mixed with tumor cells (antigens). We hypothesize that the emulsified GM-CSF in close proximity to tumor antigen peptides will substantially enhance their immunogenicity. This proximity of antigen and GM-CSF seems to be necessary for the adjuvant effect of GM-CSF, as systemic administration of

equivalent doses in animal models has not demonstrated adjuvant activity. Also, the adjuvant/local inflammatory properties of IFA may play a role in attracting antigen presenting cells to the site of injection [53]. We have preliminary data demonstrating the plausibility of such a mechanism.

- 1.9a Preliminary data demonstrating the feasibility of this approach already exists. Rosenberg and investigators published effective generation of peptide-specific T cells in melanoma patients immunized with peptides derived from gp100 [65]. Despite the demonstration of a specific immune response, no clinical responses were detected. Addition of systemic GM-CSF resulted in more pronounced CTL and delayed type hypersensitivity reactions and in a few cases objective tumor regressions. Salgaller et al. utilized a peptide derived from the gp100 epitope suspended in IFA and demonstrated generation of specific T cell responses to the peptide in melanoma patients [66]. Both studies suggest that increased immunogenicity of the peptide antigens leads to a more pronounced T cell response, which in some cases results in a clinically relevant anti-tumor effect. In the proposed study, we will combine the immunoadjuvant effects of both IFA and GM-CSF with the goal of increasing the immunogenicity of the MUC1 and HER-2/neu immunodominant peptides.

Preliminary observations in an ongoing clinical study (MC9973) utilizing HLA-A2 specific melanoma differentiation antigen peptide vaccines in which the peptide is emulsified in a suspension of IFA and GM-CSF is demonstrating enhanced skin reactions if peptide emulsified in IFA is administered in the presence of GM-CSF. A dose of 50 µg of GM-CSF in the presence of IFA and peptide results in extensive local skin reactions as well as evidence of a clinical response in one of seven patients thus far. No changes in the numbers of peptide specific CTLs were observed. However, a recent publication demonstrated superior numbers of vaccine specific CTLs generated in a peptide vaccine utilizing 225ug of GM-CSF in IFA) [67]. This would suggest a dose/response relationship of GM-CSF and anti-peptide vaccine CTL frequencies as determined by ELISPOT and tetramer assays. Therefore, in the current trial we propose to use 225ug of GM-CSF suspended in IFA (montanide ISA-51).

- 1.9b CpG
Therapeutic properties of bacteria in the treatment of malignant diseases (i.e. Coley's toxin) is an observation that has permeated the oncology literature for almost a century. More recently, it has been demonstrated that bacterial DNA possesses unique immunomodulatory features of potential utility in cancer therapy. Specifically, unmethylated CpG are able to stimulate NK cells and B cells. Furthermore, synthetic oligodeoxynucleotide (ODN) constructs containing unmethylated CpG motifs (CpG-ODN) were able to activate dendritic cells (DC) enhancing their antigen processing/presentation properties and stimulating production of Th1 cytokines necessary for CTL immune responses. Thus, CpG ODN appeared to function as an immune adjuvant. Several preclinical and clinical works illustrate the ability of CpG-ODN to function as a potent immune adjuvant for various forms of vaccines. One of the more interesting works, pertinent to this study, demonstrates the ability of CpG ODN to induce CTLs against a peptide vaccine when administered in conjunction with incomplete Freund's adjuvant (IFA) [68]. These authors used a MART-1/Melan-A₂₆₋₃₅ peptide emulsified in IFA with or without the addition of 50ug of CpG ODN to immunize human D^b (HHD) A2 transgenic mice. Their data suggest superior anti-peptide immunization in the CpG-ODN immunized group as determined by the frequency of tetramer positive CTLs. Our own data support these findings demonstrating superior immunization efficacy of IFA+CpG-ODN with ova peptide of C57BL/6 mice when compared to either IFA+peptide or complete Freund's adjuvant (CFA) + peptide (data not shown). An additional benefit to the CpG-ODN adjuvant is that it has been shown to be especially good at enhancing cellular and humoral immunity and promoting a Th1-type of response in older mice [69]. The population that develops cancer is mainly older individuals, thus the CpG-ODN adjuvant may be particularly relevant for this trial. Based on preclinical data

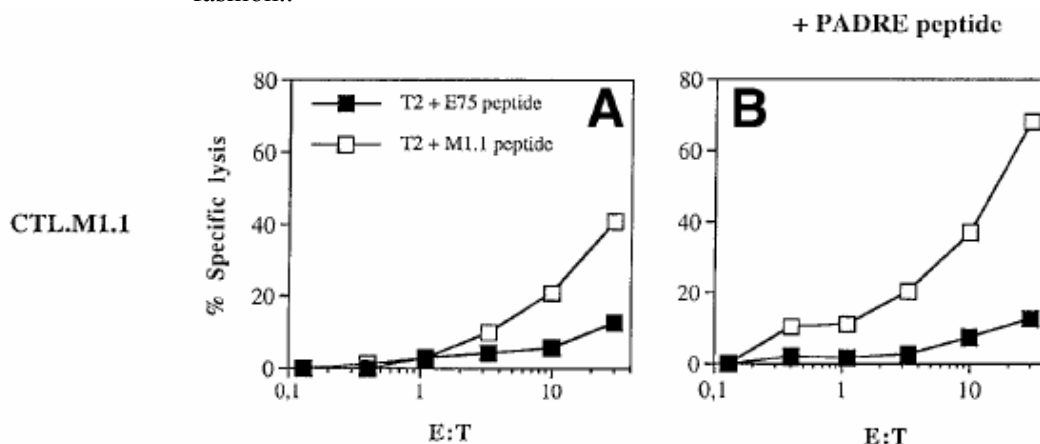
suggesting the potent immune adjuvant properties of CpG co-emulsified with peptides in IFA, we elected to test the efficacy of CpG-ODN in the setting of a peptide vaccine immunization in this clinical trial. The dose of CpG-ODN that we decided to use in this study is 2mg/vaccine. The dose is based on published data demonstrating a direct dose-dependent relationship of CpG-ODN (0.125 –1.0 mg) and magnitude of measured immune responses (HepB vaccine adjuvant [70]). This is well below the highest tested doses of 20mg/week. Based on these observations we feel that the 2mg dose is a reasonable starting point for a CpG-ODN adjuvant suspended in Montanide ISA 51 alone or in combination with GM-CSF.

1.9c Preliminary Data

Preliminary data will be presented in multiple sections. First, we will provide data to support the choice of MUC1 and HER-2/erbB2 antigenic epitopes for this trial. Next, we will define our experience using peptides to stimulate tumor reactive T cells for cancer immunotherapy. Finally, we will discuss our experience with the immune adjuvants GM-CS and CpG-ODN. These preliminary data provide a strong foundation for the current proposal.

1.9c1 Identification of CTL Epitopes from MUC1

Using a computer analysis of the MUC1 amino acid sequence, two novel peptides were identified with a high binding probability to the HLA-A2 molecule [33]. Two peptides from MUC1 were identified; one from the tandem repeat M1.1 (STAPPVHNV₉₅₀₋₉₅₈) and one from the leader sequence M1.2 (LLLLTVLTV₁₂₋₂₀). The presence of the V in position 6 increases the binding of the M1.1 peptide to the HLA-A2 molecule. There is some variability in the tandem repeats in MUC1 and this sequence is found in the last tandem repeat. Cytotoxic T cells were induced from healthy donors by primary *in vitro* immunization using peptide-pulsed dendritic cells. The peptide-induced CTL lysed tumors endogenously expressing MUC1 in an antigen-specific and HLA-A2-restricted fashion..



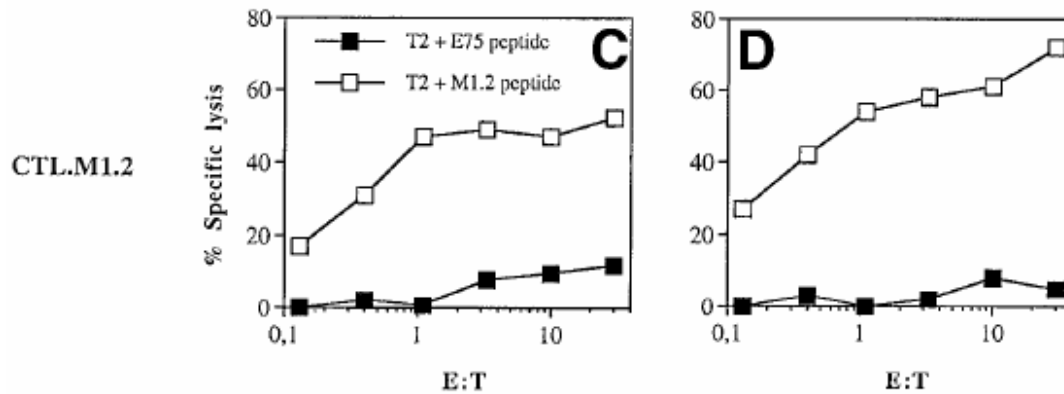


Figure 1. Induction of CTL responses by peptide-pulsed dendritic cells. Adherent peripheral blood mononuclear cells were grown for 7 days with GM-CSF, IL-4, and TNF alpha. DCs pulsed with the synthetic peptides derived from the MUC1 protein (M1.1 and M1.2) were used to induce a CTL response in vitro. In addition to the MUC1 peptide DCs were incubated with the PAN-DR binding peptide PADRE as a T-helper epitope. Cytotoxic activity of induced CTL was determined in a standard ^{51}Cr -release assay using T2 cells as targets pulsed for 2 hours with 50 μg of the cognate (open symbols) or irrelevant HER-2/neu protein-derived E75 peptide (solid symbols). (data reproduced from Brossart 1999 [33])

Next, the ability of the induced MUC1-specific CTL lines to lyse tumors expressing MUC1 was tested. MCF-7 cells that express MUC1 endogenously and are HLA-A2 positive were used as targets in a standard ^{51}Cr -release assay. The controls were SK-OV-3 cells, which express MUC1, but are HLA-A2 negative and the immortalized B cell line, Croft, which is A2 positive and was pulsed with MUC1 M1.1 or M1.2 peptides or the irrelevant HER-2/neu E75 peptide.

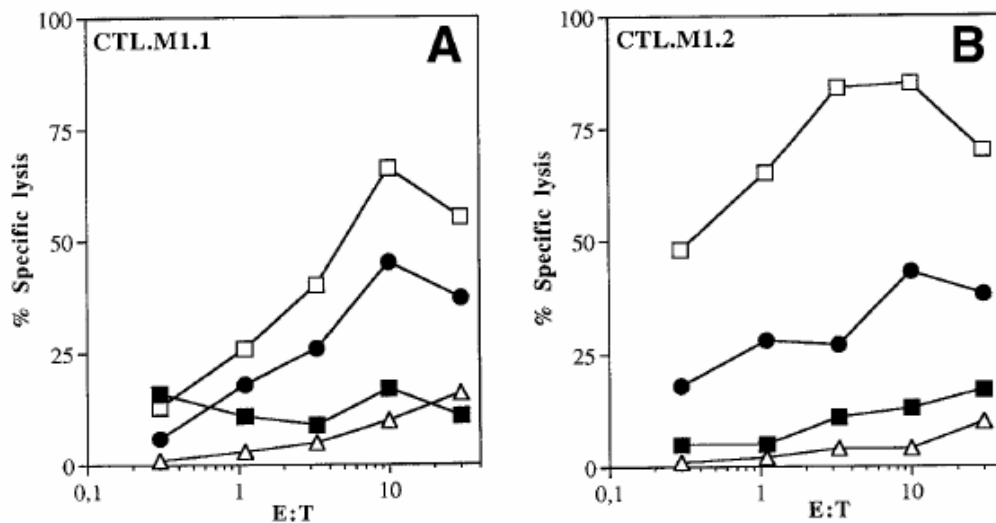


Figure 2. Lysis of cancer cells endogenously expressing MUC1 by CTL.M1.1 (A) and CTL.M1.2 (B). Human breast cancer cell line MCF-7 (HLA-A2⁺/MUC1⁺), ovarian cancer cell line SK-OV-3 (HLA-A2⁻/MUC1⁺), and the immortalized B-cell line Croft (HLA-A2⁺/MUC1⁻) were used as targets in a standard ^{51}Cr -release assay. Croft cells were pulsed with the MUC1 peptides or an irrelevant HER-2/neu-derived peptide E75. (■) Croft + E75 peptide; (□) Croft + M1.1 (A) or M1.2 (B); (●) MCF-7; (Δ) SK-OV-3.

We have chosen to use the M1.1 peptide based on the large amount of data on the response to the MUC1 tandem repeat peptide, both in the human situation as well as in the mouse. Obviously only the human data are relevant for the clinical trials. We will use a HER-2/neu helper epitope (see below, not the PADRE helper epitope)

In the case of HER-2/neu, we have identified a novel CTL epitope HER-2 (9₄₃₅), which bound HLA-A2.1 with intermediate affinity (IC₅₀ 74.6 nM). The peptide identified is: ILHNGAYSL. The .221(A2.1) cell line, produced by transferring the HLA-A2.1 gene into the HLA-A, -B, -C null mutant human lymphoblastoid cell line .221, was used as target (peptide loaded) to measure activity of HLA-A2.1 restricted CTL [71]. The CTLs elicited following in vitro stimulation effectively killed HLA-A2.1⁺ tumor cells, showing that the antigen is appropriately processed by tumors (Fig. 3A). In addition, recognition of the tumor cell target was significantly inhibited by unlabeled (cold) target pulsed with HER-2 (9₄₃₅) peptide, but not by unlabeled targets either unpulsed or pulsed with a control HLA-A2.1 binding peptide (Fig. 3B).

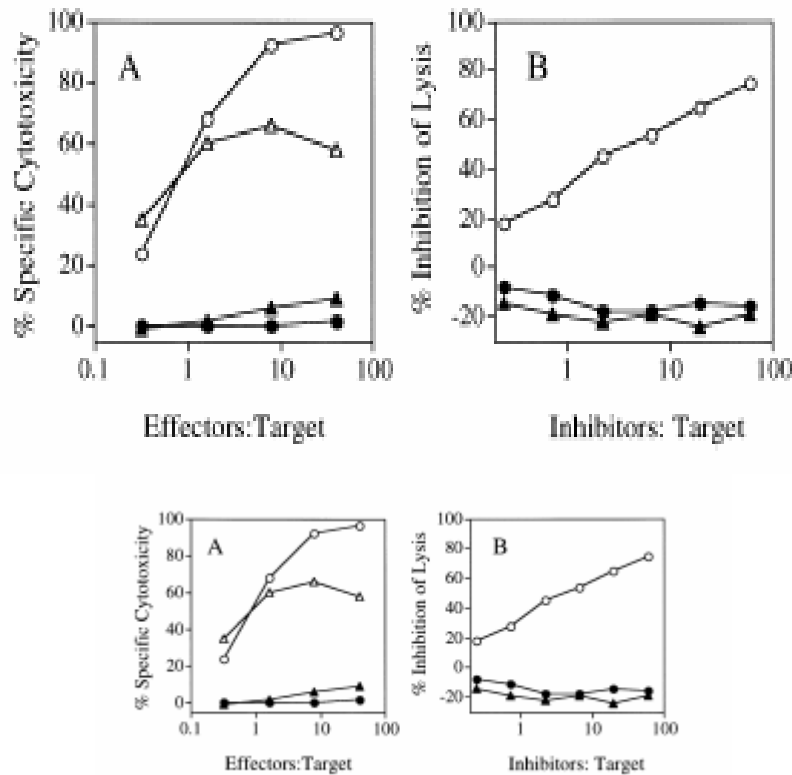


Figure 3. HER-2(9₄₃₅) specific CTL can kill tumor cells. (A) HER-2(9₄₃₅) specific CTL were used as effector cells to test for the lysis of the following target cell lines: o, .221A2.1 pulsed with HER-2(9₄₃₅); ●, .221A2.1 without peptide; Δ, SW403 (colon CA, A2⁺, HER-2/neu⁺); ▲, HT-29 (colon ca, A2⁺, HER-2/neu⁺). (B): Antigen specificity demonstrated by cold target inhibition assay. Lysis of ⁵¹Cr labeled SW403 cells at an effectors/target ratio of 10:1 by the HER-2(9₄₃₅) specific CTL was blocked at various Inhibitors/Target ratios by the following cold targets: o, .221A2.1 pulsed with HER-2(9₄₃₅); ▲, .221A2.1 pulsed with irrelevant A2.1 binding peptide (HBC₁₈₋₂₇); ●, .221A2.1 without peptide.

In addition to the class I epitopes described above, a promiscuous MHC class II epitope was defined for HER-2/neu using the algorithm tables published by Southwood et al. [58, 72]. The epitope identified is HER-2₈₈₃ (KVPIKWMALLESILRRRF). It is important to show that these peptides represent true T cell epitopes that are relevant for the development of tumor immunotherapy. For these experiments autologous PBMCs or DCs were used as APCs and recombinant DNA derived intracellular domain or extracellular domain protein fragments of HER-2/neu were used as a source of antigen. The data in Fig. 4 show that four HER-2₈₈₃-reactive T cell lines proliferated well to HER-2/neu intracellular domain protein, which encompasses the HER-2₈₈₃ peptide but not to HER-2/neu extracellular domain (ECD), which lacks HER-2₈₈₃.

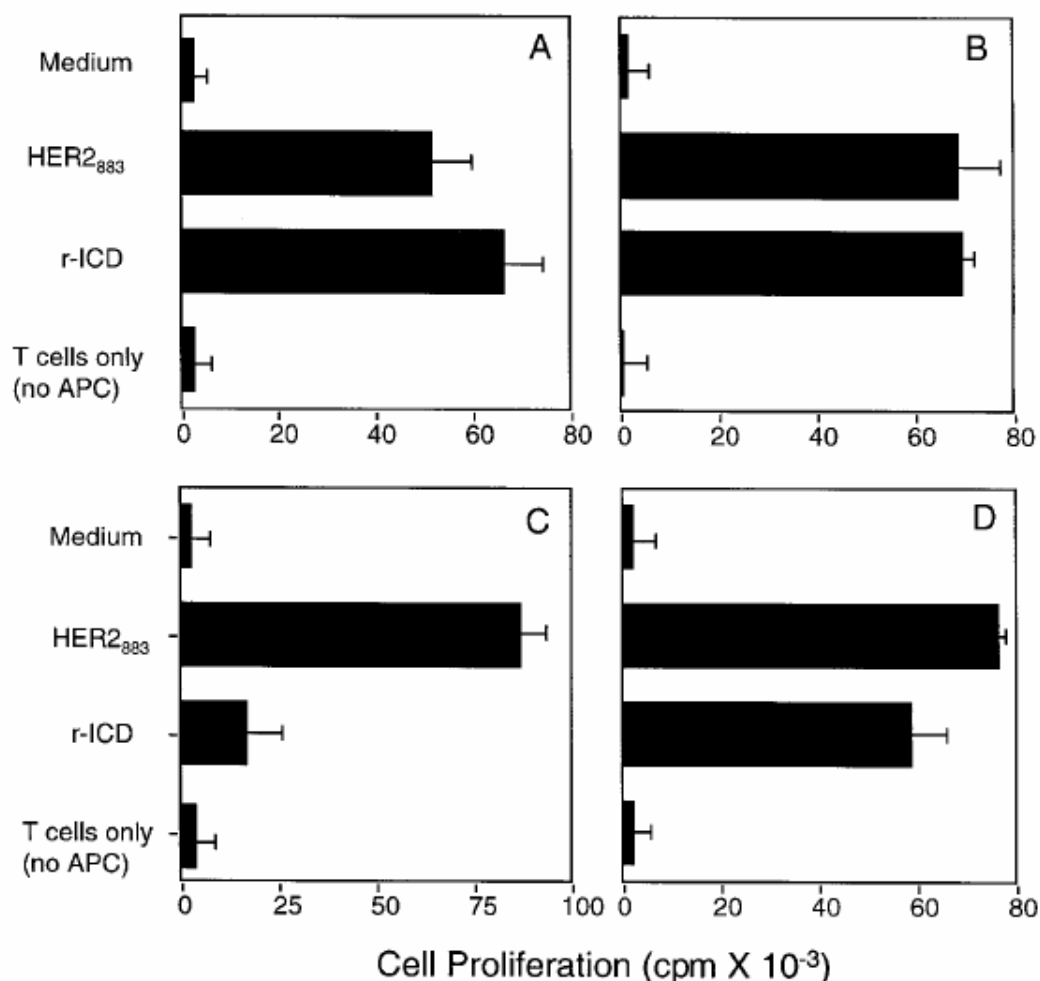
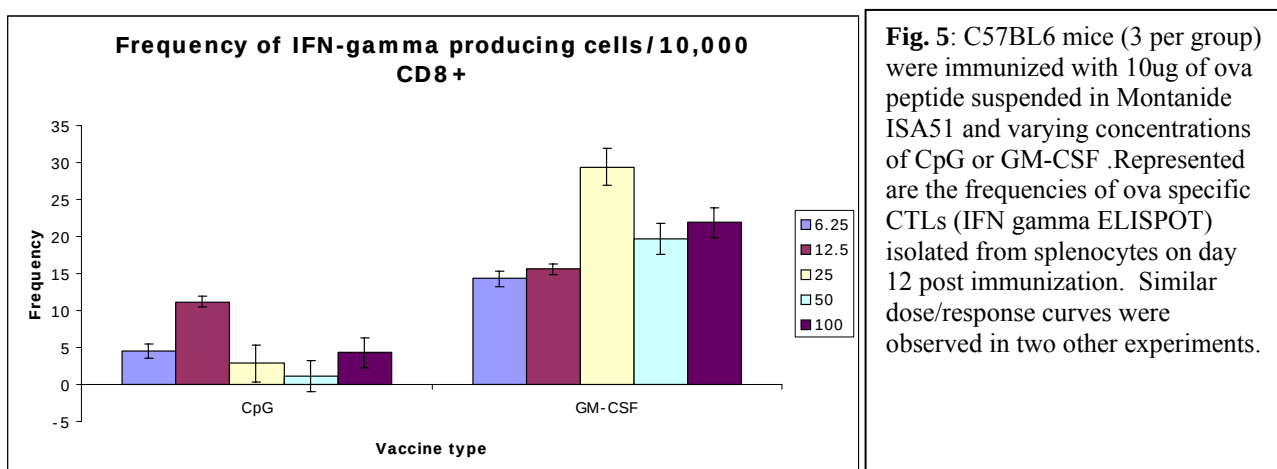


Figure 4. HER-2₈₈₃-specific CD4⁺ T cells can recognize recombinant HER-2/neu intracellular domain (r-ICD) protein presented by autologous Dcs in the context of several HLA-DR alleles. The HER-2₈₈₃-reactive HTLs, TCL-7C (panel A, HLA-DR53 restricted), TCL-6D (panel B, HLA-DR4-restricted), a clone of TCL-1D (panel C, HLA-DR52-restricted), and TCL-1E (panel D, HLA-DR53 restricted), were tested for their capacity to proliferate to autologous DCs in the presence of HER-2₈₈₃ peptide (2.5 mg/ml) or recombinant HER-2/neu recombinant ICD protein (10 mg/ml). No significant proliferative response was observed against HER-2/neu ECD protein (data not shown). Values shown are the means of triplicate determinations; bars, SD.

1.9d Justification of vaccination strategy

- 1.9d.1 **Peptide dose** (1000ug): Over the last several years there has been extensive debate over the optimal dose of peptide in a variety of peptide immunization cancer clinical trials. Peptide doses have ranged from 50ug to 2500ug in various studies. Currently, the largest peptide vaccine clinical trial (E4697) utilizes a peptide dose of 1000ug. There are several published studies evaluating peptide vaccine dose-responses [66, 73], suggesting that 1000ug of peptide would be a reasonable vaccine dose for phase I/II clinical testing.
- 1.9d.2 **GM-CSF suspended in Montanide ISA 51 as a vaccine adjuvant.** The utility of GM-CSF suspended in montanide ISA 51 as an effective vaccine adjuvant has already been demonstrated in pre-clinical and clinical studies. Our own pre-clinical data (Fig 5) demonstrates a bell shaped dose-response curve for GM-CSF co-emulsified with 10ug

of *ova* peptide in montanide ISA 51. Two weeks after immunization, the optimal dose of GM-CSF in the mouse model appears to be 100ug. In humans, Slingluff et al. demonstrated successful peptide immunization using 225ug of GM-CSF suspended in montanide ISA-51[67]. Up to 80% of treated patients demonstrated effective immunization with melanoma differentiation antigen peptides. Our clinical data using 10, 50, 75 and 100 ug of GM-CSF suspended with peptides in Montanide ISA-51 failed to demonstrate effective generation of anti-peptide CTLs. In view of these data, we felt that it was reasonable to utilize the same dose of GM-CSF used by Slingluff [67] (225ug) with our current set of peptides. If successful, further studies will be performed attempting to generate a dose-response curve of GM-CSF and immunization efficacy similar to that of the mouse model.



1.9d.3 CpG suspended in Montanide ISA 51 as vaccine adjuvant. As described in section 15.7, the co-emulsification of peptide antigens with CpG and Montanide ISA-51 is an effective means of generation of peptide specific CTLs in a pre-clinical model. Our own data confirm these findings using non-transgenic mice immunized with ova peptide co-suspended with CpG in Montanide ISA 51 (Fig. 5). The dose of CpG used in the current study was empirically selected based on the results of a phase I clinical trial utilizing CpG (abbreviated as ISS in Fig. 6 legend) as an immune adjuvant for hepatitis B vaccine immunization in healthy volunteers. In this study, volunteers were immunized with an intramuscular injection of hepatitis B vaccine (20ug) mixed with CpG in one of the following concentrations: 225ug, 650ug, 1000ug or 2250ug. A booster injection was administered 2 months later. Serologic data demonstrated (Fig 6) maximal immunization efficacy at CpG doses between 1000 and 2250ug. Based on these data suggesting a bell-shaped dose response curve for CpG (optimum may be between doses 1000ug and 2250ug) as well as our pre-clinical bell-shaped dose response curve, we elected to proceed with a CpG dose of 2000 ug.

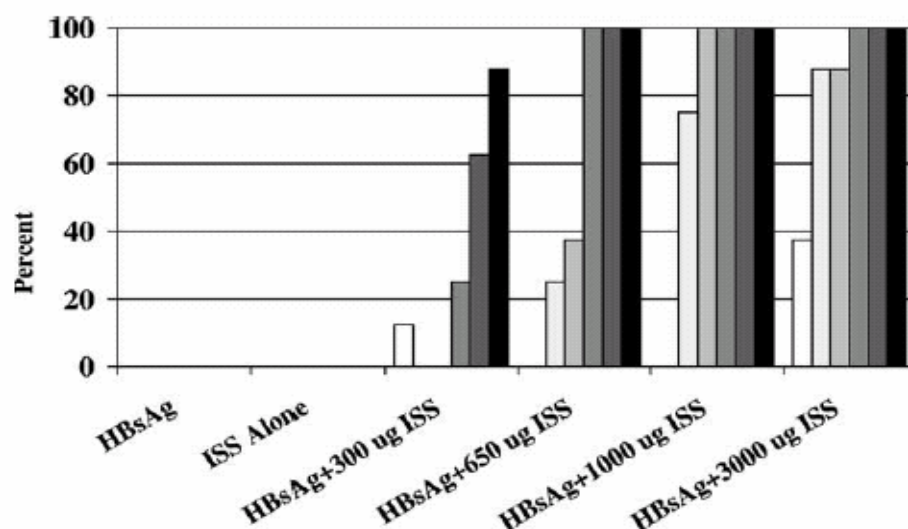


Figure 6: Proportion of participants achieving a protective antibody level ($\geq 10\text{mIU/mL}$) at various time points after immunization. Time points are (by increasing darkness of bar shade) 7 days after dose 1, 28 days after dose 1, 56 days after dose 1, 7 days after dose 2, 4 months after dose 2. CpG is designated as ISS.

The target population for this clinical trial, to whom the study findings will be generalized, are patients with a history of completely treated stage II or III breast adenocarcinoma that is MUC1 positive, currently off active therapy (with the exception of hormonal therapy) with no evidence of tumor relapse.

2.0 Goals

2.1 Primary Goal

To determine the safety and immunization efficacy of MUC1 and HER-2/neu peptide vaccines combined with CpG, GM-CSF or both, as immune adjuvants suspended in Montanide ISA-51.

2.2 Secondary Goal

To describe the impact of immunization on clinical outcomes in patients with MUC1 positive breast cancer. Clinical outcomes of interest will include: (1) **disease-free survival** defined as the time from registration to the documentation of a first failure where a failure is the recurrence (REC) of breast cancer or a diagnosis of a second primary cancer (NEWP); and (2) **overall survival** defined as the time from registration to death due to any cause.

3.0 Patient Eligibility

3.1 Inclusion criteria

3.11 Age ≥ 18 years.

3.12 Completed “standard first line therapy ONLY” (including adjuvant therapy) for breast cancer, clinical stage II and III (≥ 3 months prior to registration) and currently with no evidence of disease. Current use of “anti-estrogen” therapy is allowed.

3.13 Histologically confirmed adenocarcinoma of the breast treated with surgery, adjuvant chemotherapy, and/or radiation therapy.

3.15 MUC1 positive breast cancer by central review.

- 3.16 HLA-A2 positive.
- 3.17 The following laboratory values obtained ≤ 14 days prior to registration:
- Hemoglobin ≥ 8.0 g/dL
 - Platelets $\geq 75,000/\mu\text{L}$
 - ANC $\geq 1,500/\mu\text{L}$
 - Creatinine $\leq 2 \times \text{ULN}$
 - AST $\leq 2 \times \text{ULN}$
- 3.18 Capable of understanding the investigational nature, potential risks and benefits of the study and capable of providing valid informed consent.
- 3.19a Willingness to return to Mayo Clinic Rochester, Scottsdale, or Jacksonville for treatment and study-related follow up. Study treatment will be administered only at the Mayo Clinic site where the patient was enrolled. Post-treatment study follow-up is allowed at the other participating Mayo Clinic sites.
- 3.19b Willingness to provide the blood and tumor specimens and complete the imaging studies as required by the protocol.

Note: The goals of this study include assessment of the biologic effects on surrogate markers of the agent(s) being tested and are, therefore, contingent upon availability of the blood and tumor specimens and completion of the required imaging studies.

3.2 Exclusion criteria

- 3.21 ECOG performance status (PS) 3 or 4 (see Appendix I).
- 3.22 Uncontrolled infection.
- 3.23 Any of the following:
- Known HIV infection
 - Other circumstances (i.e. concurrent use of systemic immunosuppressants and immunocompromising condition) that in the opinion of the physician renders the patient a poor candidate for this trial
- 3.24 Failure to fully recover from acute, reversible effects of prior breast cancer therapy regardless of interval since last treatment.
- 3.25 Any of the following:
- Pregnant women
 - Nursing women unwilling to stop breast feeding
 - Women of childbearing potential who are unwilling to employ adequate contraception (diaphragm, birth control pills, injections, intrauterine device [IUD], or abstinence, etc.)

NOTE: This study involves an investigational agent whose genotoxic, mutagenic and teratogenic effects on the developing fetus and newborn are unknown.

- 3.26 Other concurrent chemotherapy, immunotherapy, radiotherapy, or any ancillary therapy considered investigational (utilized for a non-FDA-approved indication and in the context of a research investigation).

- 3.27 Radiographic evidence of disease at the time of enrollment.
- 3.28 Any prior invasive malignancies ≤ 5 years (with the exception of curatively-treated basal cell or squamous cell carcinoma of the skin or carcinoma in situ of the cervix).
- 3.29 Primary surgery for breast cancer **beyond 3 years** at time of registration.

4.0 Test Schedule

Tests and procedures	≤ 14 days prior to registration	Prior to each subsequent treatment (q 4 weeks)	At 4 weeks after last treatment	Observation q 3 months for 2 years
History and assessment, wt, PS	X	X ^R	X	X
Height	X			
Hematology group: WBC, ANC, Hgb, PLT	X ^R	X ⁸	X ^R	
Chemistry group: total and direct bilirubin, AST, creatinine.	X ^R	X ⁸	X ^R	
HLA class I and II typing ^R	At any time prior to registration			
Serum pregnancy test ¹	X			
Tumor typing ^{5R}	At any time prior to registration			
Tumor evaluation by imaging study (x-ray, CT or PET)	X			X ²
DTH skin testing (common recall antigens) ^{3, R}	X	Prior to cycle 6 only		
Research blood specimens ⁷ See section 14.0	X	X ⁴		X ⁴
Acute toxicity evaluation ⁶		X	X	

- For women of childbearing potential, must be obtained ≤ 7 days prior to registration.
 - Imaging will be performed per “standard of care” for patients and at the discretion of the treating physician
 - DTH skin testing will be performed using the same complement of antigens in routine use at the treatment site.
 - Research blood samples will be performed before registration as well as prior to **cycles 3, 5 and 6** of therapy as well as every other cycle of long-term follow-up **starting at 3 months** after completion of Rx up to two years.
 - Tumor tissues will be stained for MUC-1 and HER-2/neu.
 - Acute toxicity evaluations (physical exam and laboratory testing) will be performed for the purpose of evaluating potential immediate side effects of immunization.
 - Research blood specimens will be collected only if serum hemoglobin for the given collection is ≥ 10 g/dL. If hemoglobin is < 10 g/dL, research blood samples will be postponed until the next study office visit.
 - Research funded prior to cycles 2 and 5.
- R. Research Funded

5.0 Stratification Factors

Her-2/neu status: Positive vs. negative vs. unknown.

6.0 Registration/Randomization Procedures

- 6.1 To register a patient, access the Mayo Clinic Cancer Center (MCCC) web page and enter the remote registration/randomization application. The remote registration/randomization application is available 24 hours a day, 7 days a week. Back up and/or system support contact information is available on the Web site. If unable to access the Web site, call the MCCC Registration/Randomization Center at (507) 284-2753 between the hours of 8 a.m. and 5:00 p.m. Central Time (Monday through Friday).

The instructions for remote registration are available on the MCCC web page (<http://hsrwww.mayo.edu/ccs/training>) and detail the process for completing and confirming patient registration. Prior to initiation of protocol treatment, this process must be completed in its entirety and a MCCC subject ID number must be available as noted in the instructions. It is the responsibility of the individual registering the patient to confirm the process has been successfully completed prior to release of the study agent. Patient registration via the remote system can be confirmed in any of the following ways:

- Contact the MCCC Registration/Randomization Center (507) 284-2753. If the patient was fully registered, the Registration/Randomization Center staff can access the information from the centralized database and confirm the registration.
 - Refer to “Instructions for Remote Registration” in section “Finding/Displaying Information about A Registered Subject.”
- 6.2 A mandatory translational research component is part of this study. The patient will be automatically registered onto this component (Section 14.0).
- 6.3 A signed HHS 310 form must be on file in the Randomization Center before an investigator may register any patients. Ongoing approval documentation must be submitted (no less than annually) to the Randomization Center.
- 6.4 Prior to accepting the registration/randomization, the remote registration/randomization application will verify the following:
- IRB approval at the registering institution
 - Patient eligibility
 - Existence of a signed consent form
 - Existence of a signed authorization for use and disclosure of protected health information
- 6.5 Treatment on this protocol must commence at Mayo Clinic Rochester, Scottsdale or Jacksonville under the supervision of a medical oncologist or hematologist.
- 6.6 Treatment cannot begin prior to registration and must begin ≤ 7 days after registration.
- 6.7 Pretreatment tests/procedures must be completed within the guidelines specified on the test schedule.
- 6.8 All required baseline symptoms must be documented and graded.
- 6.9a Study drug availability checked.

7.0 Protocol Treatment

- 7.1 For the purposes of this trial, patients will be recruited from the breast cancer practice of the Mayo Clinic Cancer Center. Patients who are undergoing regular follow-up visits by Mayo Clinic oncologists, are interested in this study, and fulfill all eligibility criteria will be offered enrollment. The patients' primary physicians, co-investigators in this study, will have the opportunity to offer the study to interest patients during their regularly scheduled follow-up visits. It is not expected that recruitment or advertisement materials will be used.

The patients who are enrolled will be assigned a 'study number' which will be used for their identification, and that of their data, throughout their participation in the clinical trial.

The Informed Consent process will take place during the patient's regular follow-up visits with their oncologists, co-investigators in the clinical trial. The informed consent interview will begin as part of the patient's regular follow-up visit. At that time, interested patients will be given information about the study, and if interested, will also receive a copy of the Informed Consent document. Patients will have the opportunity to discuss the details of the study during this visit or, more likely, will be given the consent form and offered to review the document at home and schedule a follow-up visit if they are interested in taking part on the study. This way the patients will have a chance to investigate and discuss the study on their own. If interested, the patients will set-up a 2nd visit with their oncologists specifically for the purpose of deciding on study participation. At that visit, all issues of concern for the patient will be addressed, eligibility reviewed and, if appropriate, the Consent Form will be signed.

- 7.2 As part of the registration process described in Section 6.0, the Mayo Clinic Cancer Center (MCCC) Remote Registration application will assign patients to arms A through C.

- 7.3 Treatment Schedules:

Arm A

Arm A	Agent	Dose	Route	RxDays	ReRx
	Montanide ISA-51	1.2mL	subcutaneous injection in undissected LN region	Day 1 of Week 1	Q4 weeks (28-32 days) x 6 cycles
	MUC1 (STAPPVHNV)	1000ug			
	HER-2 peptide 1 (ILHNGAYSL)	1000ug			
	HER-2 peptide 2 (KVPIKWMALESIL)	1000ug			
	GM-CSF	225ug			

Arm B

Arm B	Agent	Dose	Route	RxDays	ReRx
	Montanide ISA-51	1.2mL	subcutaneous injection in undissected LN region	Day 1 of Week 1	Q4 weeks (28 days) x 6 cycles
	MUC1 (STAPPVHNV)	1000ug			
	HER-2 peptide-1 (ILHNGAYSL)	1000ug			
	HER-2 peptide-2 (KVPIKWMALESILRRRF)	1000ug			
	GpG	2mg			

Arm C

Arm C	Agent	Dose	Route	RxDays	ReRx
	Montanide ISA-51	1.2mL	subcutaneous injection in un-dissected LN region	Day 1 of Week 1	Q4 weeks (28 days) x 6 cycles
	MUC1 (STAPPVHNV)	1000ug			
	HER-2 peptide-1 (ILHNGAYSL)	1000ug			
	HER-2 peptide-2 (KVPIKWMALESILRRRF)	1000ug			
	GM-CSF	225ug			
	CpG	2mg			

- 7.4 Fifteen patients per arm (total of 45) will be randomly assigned to receive one of the three treatment schedules. Doses will not be escalated in any individual patient. It is not anticipated that there will be toxicity experienced with these regimens.

Vaccines will be prepared in a single vial and administered as multiple (2-3) subcutaneous injections in regions of un-disturbed axillary or inguinal lymph nodes. Each vaccine cycle will be administered into a single lymph node draining area. Subsequent vaccination cycles will be administered to other (rotating) undisturbed lymph node drainage sites.

The main risks are those of an allergic reaction to the components of the peptide vaccine (local or systemic). To minimize risk, patients will be observed by a registered nurse for 30 minutes following each immunization. On-site physicians will be available in the unlikely event that complications do occur. Risks due to phlebotomy will be minimized by ensuring that all patients will undergo phlebotomy by certified phlebotomists. All patients will be provided detailed contact information so that they are able to contact their treating physicians/co-investigators if they experience problems (medical or otherwise) while undergoing therapy in this study.

There are no antidotes available for the peptide vaccines used in this protocol. If patients develop symptoms as a result of the vaccines (e.g. allergic reactions), those patients will be treated accordingly.

The benefit to patients who undergo treatment in this study is unknown.

As IND sponsor, the Principal Investigator will monitor the protocol in accordance with 21 CFR 312, as indicated in portions of section 4.0, the test schedule; section 10.0, the adverse event reporting; and section 15, the drug information.

8.0 Dosage Modification Based on Adverse Events - Adjustments are based on adverse events observed since the prior dose.

ALERT: *ADR reporting may be required for some adverse events (See Section 10)*

→ → Use Common Terminology Criteria for Adverse Events (CTCAE) v3.0 unless otherwise specified ← ←			
CTCAE CATEGORY	ADVERSE EVENT	AGENT	DOSAGE CHANGE OR OTHER ACTION
AT TIME OF RETREATMENT			
ALLERGY/ IMMUNOLOGY	≥Grade 2 allergic reaction/ hypersensitivity	Montanide	Discontinue vaccinations indefinitely and begin event monitoring.
	≥Grade 2 autoimmune reaction (excluding vitiligo)	GM-CSF	Discontinue vaccinations indefinitely and begin event monitoring.
ALL OTHERS	≥Grade 3 Hematologic or ≥Grade 3 Nonhematologic (excluding alopecia) ≥Grade 2 neurologic	CpG Peptides	Discontinue vaccinations indefinitely and begin event monitoring.

9.0 Ancillary Treatment/Supportive Care

- 9.1 Patients should receive blood product support, antibiotic treatment and treatment of other newly diagnosed or concurrent medical conditions.
- 9.2 Patients participating in this clinical trial are not to be considered for enrollment in any other study involving a pharmacologic agent (drugs, biologics, immunotherapy approaches, gene therapy) whether for symptom control or therapeutic intent.

10.0 Adverse Event (AE) Reporting and Monitoring

- 10.1 This study will utilize the Common Terminology Criteria for Adverse Events (CTCAE) v3.0 for adverse event monitoring and reporting. The CTCAE v3.0 can be downloaded from the CTEP home page (http://ctep.info.nih.gov/CTC3/ctc_ind_term.htm). All appropriate treatment areas should have access to a copy of the CTCAE v3.0.
- 10.11 Adverse event monitoring and reporting is a routine part of every clinical trial. First, identify and grade the severity of the event using the CTCAE. Next, determine whether the event is expected or unexpected (refer to Section 15.0 and/or product literature) and if the adverse event is related to the medical treatment or procedure (see Section 10.12). With this information, determine whether an adverse event should be reported as an expedited report (see Section 10.2) or as part of the routinely reported clinical data.
- Expedited adverse event reporting requires submission of a written report, but may also involve telephone notifications. Telephone and written reports are to be completed within the timeframes specified in Section 10.2. All expedited adverse event reports should also be submitted to the local Institutional Review Board (IRB).

10.12 Assessment of Attribution

When assessing whether an adverse event is related to a medical treatment or procedure, the following attribution categories are utilized:

Definite - The adverse event *is clearly related* to the investigational agent(s).

Probable - The adverse event *is likely related* to the investigational agent(s).

Possible - The adverse event *may be related* to the investigational agent(s).

Unlikely - The adverse event *is doubtfully related* to the investigational agent(s).

Unrelated - The adverse event *is clearly NOT related* to the investigational agent(s)

10.2 Expedited Adverse Event Reporting Requirements

Phase I, II and III Studies (Investigational)

	Grade 4 or 5 ¹ Unexpected with Attribution of Possible, Probable, or Definite	Other Grade 4 or 5 or Any hospitalization during treatment ⁶	Secondary AML/MDS ²
Notify the Cancer Center IND Coordinator ³ within 24 hours	X		
Submit written report within 5 working days ⁴	X		
NCI/CTEP Secondary AML/MDS Report Form within 15 working days ⁵			X
Submit Grade 4 or 5 Non-AER Reportable Events/Hospitalization Form within 5 working days. ⁶		X ⁶	

1. Includes all deaths within 30 days of the last dose of investigational agent regardless of attribution or any death attributed to the agent(s) (possible, probable, or definite) regardless of timeframe.
2. Reporting for this AE required during or after treatment.
3. Notify the Cancer Center IND Coordinator (Mayo Clinic - Rochester) by telephone (507) 284-0938 and/or submit a written event summary via fax to (507) 538-7164.
4. Use *Adverse Event Expedited Report – Single Agent* or *Multiple Agents* report form. Submit to the Cancer Center IND Coordinator (Mayo Clinic - Rochester) and to the Cancer Center Protocol Development Coordinator (PDC) for IRB reporting. The IND Coordinator will review the event in consultation with the IND holder and report to the Food and Drug Administration (FDA) as warranted by the event and required by U.S. federal regulations.
5. Submit per form-specified instructions and provide copy to Cancer Center IND Coordinator for review and FDA reporting (as warranted by the event) and the Cancer Center PDC for IRB reporting.
6. In addition to standard reporting mechanism for this type of event, submit information to the Cancer Center IND Coordinator and Cancer Center PDC. These persons will facilitate FDA and IRB reporting, respectively, as warranted by the event. If Adverse Event Expedited Report – Single Agent or Multiple Agents report form was completed, this form does not need to be completed.

- 10.3 Adverse events to be graded at each evaluation and pretreatment symptoms/conditions to be evaluated at baseline per Common Terminology Criteria for Adverse Events (CTCAE) v3.0 grading unless otherwise stated in the table below:

CTCAE Category	Adverse event/Symptoms	Baseline	Each evaluation
Constitutional Symptoms	Fatigue	X	X
Dermatology/Skin	Injection site reaction		X
	Rash/desquamation	X	X
Pain – Select Musculoskeletal	Bone	X	X
	Joint	X	X
	Muscle	X	X

- 10.31 Submit via appropriate MCCC Case Report Forms (i.e., paper or electronic, as applicable) the following AEs experienced by a patient and not specified in Section 10.3:
- 10.311 Grade 2 AEs deemed *possibly, probably, or definitely* related to the study treatment or procedure.
- 10.312 Grade 3, 4, and 5 AEs and deaths within 30 days of the patient's last treatment, regardless of attribution to the study treatment or procedure, with the exception of signs or symptoms of definitely related to the patient's disease or disease progression.
- 10.313 Any death more than 30 days after the patient's last study treatment or procedure which is felt to be at least possibly treatment related must also be submitted as a Grade 5 AE, with a CTCAE type and attribution assigned.
- 10.32 Refer to the instructions in the electronic data entry screens regarding the submission of late occurring AEs following completion of the Active Monitoring Phase (i.e., compliance with Test Schedule in Section 4.0).

**Information included at the request of the Department of Defense,
a financial sponsor of the study**

Reporting of serious or unexpected adverse events and unanticipated problems.

- a. Serious or unexpected adverse events and unanticipated problems can occur in any and all types of studies, not just experimental interventions or clinical trials.
- b. Include a definition of what constitutes an adverse event in the study.
 - (1) For IND or IDE research include definitions as described in 21 CFR 312.32.
 - (2) All IND protocols must address the following requirements.

“An adverse event temporally related to participation in the study should be documented whether or not considered to be related to the test article. This definition includes

intercurrent illnesses and injuries and exacerbations of preexisting conditions. Include the following in all IND safety reports: Subject identification number and initials; associate investigator's name and name of MTF; subject's date of birth, gender, and ethnicity; test article and dates of administration; signs/symptoms and severity; date of onset; date of resolution or death; relationship to the study drug; action taken; concomitant medication(s) including dose, route, and duration of treatment, and date of last dose."

- c. Describe agencies or offices to be notified with point of contact information in the event of a serious and unexpected adverse event.

All protocols should contain the following language regarding the HSRRB reporting requirements for adverse events and unanticipated problems. (Note that unanticipated problems can occur in a study that does not require a research/clinical intervention.)

"Unanticipated problems involving risk to volunteers or others, serious adverse events related to participation in the study and all volunteer deaths should be promptly reported by phone (301-619-2165), by email (hsrrb@det.amedd.army.mil), or by facsimile (301-619-7803) to the Army Surgeon General's Human Subjects Research Review Board. A complete written report should follow the initial telephone call. In addition to the methods above, the complete report can be sent to the U.S. Army Medical Research and Materiel Command, ATTN: MCMR-ZB-QH, 504 Scott Street, Fort Detrick, Maryland 21702-5012"

Refer to the "HSRRB Information Sheet for Investigators: Unanticipated Problems" for examples of unanticipated problems located on our website.

"The medical monitor for this project, Dr. Ravi Rao, is required to review all unanticipated problems involving risk to volunteers or others, serious adverse events and all volunteer deaths associated with the protocol and provide an unbiased written report of the event. At a minimum the medical monitor should comment on the outcomes of the event or problem and in the case of a serious adverse event or death comment on the relationship to participation in the study. The medical monitor should also indicate whether he/she concurs with the details of the report provided by the study investigator. Reports for events determined by either the investigator or medical monitor to be possibly or definitely related to participation and reports of events resulting in death should be promptly forwarded to the HSRRB."

The medical monitor will forward reports to the U.S. Army Medical Research and Materiel Command, ATTN: MCMR-ZB-QH, 504 Scott Street, Fort Detrick, Maryland 21702-5012.

11.0 Treatment Evaluation

- 11.1 For the purposes of this study, patients should be re-evaluated every 4 weeks during immunizations (treatment) and every 12 weeks during follow-up.
- 11.2 At the time of reevaluation, patients will be classified in the following manner:
 - 11.21 No evidence of disease (NED).
 - 11.22 Breast cancer recurrence (REC). Local/regional breast cancer recurrence is defined as the development of tumor (except LCIS) in the ipsilateral breast (after lumpectomy); in the soft tissue/chest wall and/or skin of the ipsilateral chest wall; or tumor in the

ipsilateral internal mammary, infraclavicular, or axillary nodes or soft tissue of ipsilateral axilla. Suspected tumor recurrence in the ipsilateral breast, chest wall structures or lower (level I $\pm$ II) axillary nodal areas must be confirmed by biopsy or cytology. Histologic or cytologic confirmation of tumor is recommended for internal mammary or infraclavicular/high axillary nodal recurrence. A distant recurrence is defined as development of tumor in areas other than the local/regional area that is documented by a positive cytology aspirate, biopsy, or imaging studies.

11.23 New primary (NEWPR): A new primary is defined as the development of contralateral breast cancer or a second cancer other than squamous or basal cell carcinoma of the skin, carcinoma in situ of the cervix or LCIS of the breast that is histologically confirmed.

11.3 Further treatment after the documentation of a breast cancer recurrence or second primary cancer is left to the discretion of the treating physician.

12.0 Descriptive Factors: None.

13.0 Treatment/Follow-up Decision at Evaluation of Patient

13.1 Patients who have not recurred at time of their reassessment and have not experienced intolerable toxicity may continue protocol treatment at the same dose level for a maximum of 6 cycles or until progression of disease, a second primary or an intolerable adverse event occurs.

13.2 Patients who develop progression of disease, a second primary or intolerable toxicity will be removed from protocol treatment and go to the event monitoring phase of the study. Subsequent treatment is at the discretion of the treating physician.

13.3 Patients may refuse further protocol treatment at any time and go to the event-monitoring phase of the study.

13.4 If a patient is declared ineligible by the study team, on-study material, treatment evaluation forms, and end of treatment form should be submitted. No further follow-up after notification of ineligibility is required.

13.5 If a patient is declared a cancel by the study team, on-study material should be submitted. No further follow-up is required.

13.6 If patient is found on central review of MUC1 negative, the patient will be considered a cancel.

13.7 There will be no replacement of patients who discontinue or are removed from the protocol for any reason.

14.0 Correlative/Translational Studies

14.1 Description of Assays

Active vaccines for the immunotherapy of solid tumors have met with only limited success. It is our hypothesis that the causes of this failure are multifactorial and can be improved by the inclusion of stringent patient selection criteria, careful dose titration based on immunologic response monitoring, and correlation of immunologically based dosing parameters with clinical outcome. The following sections define the strategies that will be employed in this trial to evaluate immunologic response to MUC1, and HER-2 peptides.

14.11 Immune Responses to T Helper and CTL Epitopes

14.111 Elispot

Estimates of frequencies of peptide-specific, IFN γ - and IL-5-producing cytotoxic T lymphocytes and helper T lymphocytes will be obtained by ELISPOT assays following *in vitro* stimulation with peptide-sensitized stimulator cells [74, 75]. IL-5 production, rather than that of IL-4, will be assayed because of the increased signal:noise ratio [74]. CD8⁺ and CD4⁺ T cells will be positively selected by magnetic activated cell sorting (MACS, Miltenyi Biotech) from cryopreserved and thawed peripheral blood lymphocyte buffy coat. Antigen-presenting cells (APCs) will also be isolated from CD4⁺/CD8⁻ cell population by MACS (beads and reagents purchased from Miltenyi Biotech). CD8⁺ and CD4⁺ responder T cells will be stimulated with irradiated APCs pulsed with the target peptides used for vaccination. After 5 days of co-culture, the responding cells will be diluted, titrated, and re-stimulated with APCs pulsed with target peptides for 24 hours in 96 well microtiter ELISPOT plates coated with IFN γ - or IL-5-specific capture antibody (ELISPOT Kit purchased from MABTECH, Stockholm, Sweden). The target peptides for re-stimulation include the peptide used for primary stimulation (MUC1 and HER-2 peptides) and a negative control peptide (YIGEVLSV). The wells are washed and treated with ALP-conjugated secondary antibody and cytokine-producing spots detected using appropriate substrate (all reagents are provided in the kit). After stopping the reaction, the developed microtiter plates are shipped to Zellnet Consulting in New York for evaluation of number of spot-producing cells for each responder cell titration. All analyses are performed by the consulting firm and data provided electronically to the investigator. The difference between the frequency of spot-producing cells obtained with the target peptides and control peptide will determine the frequency of peptide-specific, cytokine-producing CD4⁺ or CD8⁺ T cells.

14.112 Tetramers

The estimation of frequencies of CTLs that recognize specific peptides bound to class I molecules became increasingly easier and more quantifiable with the construction and application of class I tetramers [11, 76, 77]. Class I MHC tetramers are composed of a complex of four HLA MHC class I molecules each bound to the specific peptide and conjugated with a fluorescent protein (MHC Tetramer-Streptavidin-Phycoerythrin (SA-PE)). We will use MUC1 M1.1 peptide (STAPPVHNV) and HER-2/neu peptide₉₄₃₅ (ILHNGAYSL). To detect epitope spreading, we will also use HER-2/neu peptide₃₆₉₋₃₇₇ (KIFGSLAFL). As a negative control, we will use the multi-allele negative tetramer from Beckman Coulter (T01044). For positive control we will use the HLA-A0201 CMV PP65 tetramer (NLVPMVATV) from Beckman Coulter (T01009). Tetramers of HLA-A2 molecules are commercially available (Beckman Coulter). On the day of staining, test PBLs are thawed, washed, and resuspended in the manufacturer's recommended staining buffer (PBS) at 1×10^6 cells/ml. Tetramers and any additional antibodies (such as anti-CD8 or anti-CD3 conjugated to a different fluor such as FITC) are added to the cell volumes and incubated for 30 min at room temperature. The cell suspension is then washed with PBS and resuspended in PBS with 0.5% formaldehyde (Fixative Reagent) and analyzed by flow cytometry with FACSCAN

instrumentation and CellQuest software (BD Biosciences); a minimum of 5×10^5 cells/sample are analyzed for accurate estimation of CD8⁺ CTLs with low frequencies. The analysis involves (1) gating on lymphocytes using forward and side-scatter; (2) gating on FITC-positive PBLs that stain with anti-CD3 or anti-CD8, and (3) analyzing the gated cells for PE and FITC staining. The frequency of doubly stained cells (tetramer⁺/CD8⁺) will be estimated for each of three replicate tubes for calculation of the mean frequency ($\pm$ sd).

14.12 Antigenic Profiling

14.121 Expression of Class I HLA Antigens on tumor tissue.

Initial entry criteria require HLA-A typing of peripheral blood with subsequent confirmation of HLA class I antigen expression on tumor cells by immunohistochemistry. One of the mechanisms by which tumors are postulated to evade the immune response is by down regulation of classical HLA molecules necessary for antigen presentation.

14.122 Tumor Expression of MUC1 and HER-2

Tumor blocks will be used to determine the levels of expression of HER-2 and MUC1 on breast cancer tumor cells obtained at the time of most recent surgical resection. HER-2 expression will be determined using a clinical grade test +1 to +3 and levels of expression will be graded on a semi-quantitative scale. MUC1 expression will be determined by positive staining with one of several antibodies to MUC1 (HMFG-2, BC-2, or B27.29). Negative controls will be incubated with PBS instead of monoclonal antibody. Staining of cytoplasm and plasma membrane will be evaluated. Cells will be considered positive when at least one of these components is stained. Antibody staining patterns will be scored in a semi quantitative manner from +1 to +3.

14.13 Sample Schedule

14.131 Blood

100 mL of blood (about 7 tablespoons) will be collected (heparin) prior to registration and prior to each subsequent immunization as well as every 3 months after conclusion of active therapy until 24 months following registration. Prior to each study blood collection a complete blood count will be performed. If the serum hemoglobin is less than 10.0, the study sample will not be collected. Study sample collection will be postponed for the next study visit.

14.132 Tumor

Tumor blocks will be collected from the patient's most recent surgery prior to study registration. Sections from the tumor blocks will be stained for MUC1. Any/all remaining tissue samples will be returned to the clinical file. Any/all excess samples will be destroyed.

14.14 Sample Preparation

14.141 Blood

Peripheral blood lymphocytes (PBLs) are enriched by flotation over Ficoll-Hypaque and frozen in aliquots in 10% DMSO for storage at -150°C. Percentages of CD4⁺ and CD8⁺ T cells, B cells, monocytes, and dendritic cells are estimated by flow cytometry with a panel of specific monoclonal antibodies. In addition, proliferation assays (3H-thymidine uptake) are performed to estimate T cell responses to polyclonal stimulus (phytohemagglutinin), target antigens (MUC1 and HER-2/neu) and a recall antigen (tetanus toxoid). These two sets of experiments are important for estimating the representation of individual lymphoid populations and evaluating overall T cell responsiveness. CD8⁺ (CTLs) and CD4⁺ (HTLs) are positively purified from cryopreserved and thawed PBLs by magnetic bead separation (Miltenyi Biotek). Additionally, serum will be collected and stored from each of these samples. Cells will then be frozen and stored at -150° for future use.

14.3 Delayed-type hypersensitivity (DTH) skin testing

Skin testing (baseline - prior to registration) will be coordinated through the Mayo Immunization/Allergy Clinic (L-15). A typical panel includes candida, mumps, PPD, and trichophyton. Other antigens may be substituted in the event of antigen unavailability. Patients will return for 1-2 follow-up measurements consistent with L-15 procedures. Patients must have a “positive” reaction to at least one of the antigens tested, to be considered eligible for participation. Patients with only “doubtful” or “negative” reactions will not be considered eligible.

15.0 Drug Information15.1 MUC-1 (STAPPVHNV) - *Investigational supply*

15.11 Other Names: epithelial membrane antigen (EMA), polymorphic epithelial antigen (PEM), DF3 antigen, Ca1, MAM-6, H23, episialin

15.12 Formulation and Storage: Samples will be vialled (glass vials with Teflon coated stoppers) as powder at a concentration of 1.2mg/vial and kept frozen at 120°C until use.

15.13 Drug Procurement and Accountability: to be purchased from Clinalfa

15.2 HER-2 Peptide-1 (ILHNGAYSL) - *Investigational supply*

15.21 Other Names: erbB2, neu

15.22 Formulation and Storage: Samples will be vialled (glass vials with teflon coated stoppers) as powder at a concentration of 1.2mg/vial and kept frozen at -20°C until use.

15.23 Drug Procurement and Accountability: to be purchased from Clinalfa

15.3 HER-2 Peptide-2 (KVPIKWMALESILRRRF) - *Investigational supply*

15.31 Other Names: erbB2, neu

- 15.32 Formulation and Storage: to be determined
Samples will be vialled (glass vials with teflon coated stoppers) as powder at a concentration of 1.2mg/vial and kept frozen at –20°C until use.
- 15.33 Drug Procurement and Accountability: to be purchased from Clinalfa
- 15.4 Montanide ISA-51 Adjuvant [MONTAN] - *Investigational supply*
- 15.41 Formulation and Storage
- Montanide ISA-51 is an oil-based adjuvant product similar to Incomplete Freund's Adjuvant. Which when mixed with a water-based solution on 1:1 w/w ration, forms a water-in-oil emulsion. It consists of highly purified oil, Drakol VR, and a surfactant, mannide oleate. Montanide ISA-51 is manufactured by Seppic, Inc., and is provided in amber glass ampoules containing 3 mL of the solution. Montanide ISA-51 will be purchased from Seppic Inc.
- 15.42 Mode of Action
- Acts to enhance immune response to vaccination; the precise mode of action is unknown.
- 15.43 Storage and Stability
- The solution is stored at controlled room temperature. Exposure to cold temperatures may result in a clouded solution, which should be discarded. An expiration date is printed on the ampoule label.
- 15.44 Compatibilities/Incompatibilities
- The oil may break down the rubber tip of the plunger on syringes; it is advisable to use a different syringe for each ampoule. Do not allow the Montanide ISA-51 to be in direct contact with the rubber tip of the plunger for more time than is necessary to withdraw the solution and inject it into the peptide vial. Fresh syringes will be needed to withdraw the emulsified vaccine from the vaccine vial. Once the emulsion is made, there is less interaction of the oil directly with the rubber tip of the plunger.
- 15.45 Drug Procurement and Accountability
- Montanide ISA-51 will be purchased from Seppic Inc. The Cancer Center Pharmacy Shared Resource will store the drug and maintain records of inventory and disposition of all agent received.
- 15.5 GM-CSF (sargramostim, Leukine®)
- 15.51 Preparation and Storage
- Liquid (used in this study) is available in vials containing 500 mcg/mL (2.8×10^6 IU/mL) sargramostim. Carton of 5 multiple-dose vials; each vial contains 1 mL of preserved 500 mcg/mL LEUKINE Liquid (NDC 50419-050-30). LEUKINE should be refrigerated at 2-8°C (36-46°F). Do not freeze or shake. Do not use beyond the expiration date printed on the vial.

15.52 Known Potential Toxicities

Fever, chills, asthenia, malaise, numbness, increased sensitivity to touch, loss of balance, dizziness, rash, peripheral edema, dyspnea, headache, pericardial effusion, bone pain, arthralgia, nausea, vomiting, loss of appetite, developing or worsening of kidney or liver problems, difficulty breathing, shortness of breath, redness of the skin, facial flushing, rapid or irregular heartbeat or other heart problems, low blood pressure, myalgia, and serious allergic reactions such as a severe asthma attack.

15.53 Drug Procurement:

Leukine 500 mcg vials are available commercially. Drug will be purchased for this project using study grant funds. Patients will not be charged for the GM-CSF.

15.6 CpG-7909 (Promune™)

15.61 Preparation and Storage: CpG-7909 is formulated as a sterile phosphate buffered saline solution (5mg/mL) stable for parenteral administration. The sterile and pyrogen free solution contains no preservatives. Vials are intended for single entry; penetration of the vial's stopper should only be done once to maintain sterility. The drug product is packaged in clear, Type I USP glass vials with teflon-coated stopper closure and flip-caps. The drug product should be stored under refrigeration (2-8°C). CpG-7909 is stable for at least one year if stored frozen.

15.62 Known potential toxicities: The list of reported serious adverse events with the use of CpG-7909 demonstrates the following toxicities:

15.621 **Related:** reactive follicular lymphatic hyperplasia.

15.622 **Possibly Related:** anemia, superior vena cava syndrome, dyspnea, malignant ascites, post-operative bleeding, hepatic failure, renal failure, post-operative wound infection, GI hemorrhage, prolonged coagulation time, bacteriemia, ureteric obstruction, congestive heart failure, DVT, vomiting, dehydration, vein compression, hydronephrosis, urinary retention, proctalgia, hypercalcemia, pleural effusion, subacute inflammatory demyelinating polyneuropathy, pelvic inflammatory disease, unstable angina, myocardial infarction, atrial fibrillation and grand mal seizures.

15.63 Drug Procurement: to be purchased from Coley Pharmaceutical Group Inc.

15.7 Vaccine Preparation Instructions

15.71 General Vaccine Preparation Information

Emulsify the peptide(s)/GM-CSF or CpG mixture with Montanide ISA-51. Prepare the vials as directed for each group below. Place the vial upside down in a tube platform holder of a vortex machine and vortex at highest speed for 12 minutes. This will minimize the amount of emulsion adhering to the inside surface of the vial. Because neither the peptide solution nor the Montanide ISA-51 contains preservatives or bacteriostatics, the prepared peptide vaccines should be administered as soon as possible.

15.711 Arm A

Remove the peptide vials from the freezer and thaw at room temperature. Remove a vial of liquid GM-CSF (500 mcg/mL) from the refrigerator and allow to reach room temperature. Withdraw 700µL of GM-CSF and add to the peptide vial containing 1.2 mg of peptide. Suspend the first peptide in the solution, withdraw the mixture and add it to the 2nd peptide vial. Repeat the same procedure and re-suspend the 3rd peptide vial. In the 3rd vial also, 1.0 mL of Montanide ISA-51 to the peptide vial. Place the vial upside down in a tube platform holder of a vortex machine and vortex at the highest speed for 12 minutes. This will minimize the amount of emulsion adhering to the inside surface of the vial. Load two tuberculin syringes with equal volumes of this emulsion prior to use). Correct emulsification will be tested by carefully placing a small droplet of the emulsion on the surface of ice-cold distilled water (in a small 10 mL beaker) and observing that the droplet does not disperse after 2 minutes. Discard unused GM-CSF and peptide solution. Each syringe will be identified with the patient's name and confirmed by a second pharmacist. The nurse will administer the vaccine mixture to the patient as soon as possible.

Arm B

Remove the peptide vials from the freezer and thaw at room temperature. Remove a vial of liquid CpG-7909 (5mg/vial/mL) from the refrigerator and allow to reach room temperature. Withdraw 0.5mL of CpG-7909 and add to the first peptide vial containing 1.2 mg of peptide. Suspend the first peptide in the solution, withdraw the mixture and add it to the 2nd peptide vial. Repeat the same procedure and re-suspend the 3rd peptide vial. In the 3rd vial also add 1.0 mL of Montanide ISA-51. Place the vial upside down in a tube platform holder of a vortex machine and vortex at the highest speed for 12 minutes. This will minimize the amount of emulsion adhering to the inside surface of the vial. Load two tuberculin syringes with equal volumes of this emulsion prior to use). Correct emulsification will be tested by carefully placing a small droplet of the emulsion on the surface of ice-cold distilled water (in a small 10 mL beaker) and observing that the droplet does not disperse after 2 minutes. Discard unused CpG and peptide solution. Each syringe will be identified with the patient's name and confirmed by a second pharmacist. The nurse will administer the vaccine mixture to the patient as soon as possible.

Arm C

Remove the peptide vials from the freezer and thaw at room temperature. Remove a vial of liquid GM-CSF (500 mcg/mL) from the refrigerator and allow it to reach room temperature. Remove a vial of liquid CpG-7909 (5mg/vial/mL) from the refrigerator and allow it to reach room temperature. Withdraw 0.5mL of CpG-7909 and add to the first peptide vial containing 1.2 mg of peptide. Suspend the first peptide in the solution, withdraw the mixture and add it to the 2nd peptide vial. Repeat the same procedure and re-suspend the 3rd peptide vial. In the 3rd vial also add 1.0 mL of Montanide ISA-51 to the peptide vial. Finally, add 0.6mL of GM-CSF to the mixture. Place the vial upside down in a tube platform holder of a vortex machine and vortex at the highest speed for 12 minutes. This will minimize the amount of emulsion adhering to the inside surface of the vial.

Load two to three tuberculin syringes with equal volumes of this emulsion prior to use). Correct emulsification will be tested by carefully placing a small droplet of the emulsion on the surface of ice-cold distilled water (in a small 10 mL beaker) and observing that the droplet does not disperse after 2 minutes. Discard unused GM-CSF, CpG-7909 and peptide solution. Each syringe will be identified with the patient's name and confirmed by a second pharmacist. The nurse will administer the vaccine mixture to the patient as soon as possible.

15.8 Vaccine Administration Information

15.81 Dose Specifics

Each peptide vaccine will consist of a total volume of approximately 2 to 4 mL, containing the correct dose of the peptide(s), Montanide ISA-51, and GM-CSF or CpG. Be sure to confirm the proper cohort and dose level before preparing the product.

15.82 Administration

Vaccinations will be given subcutaneously on day 1 of each treatment cycle. Due to the large volume, each peptide vaccine is administered in 2 to 3 shots in a contiguous location the peptide vaccine should be injected in the vicinity of one of the major nodal basins. This basin must not have been dissected.

15.9 Vaccine Side Effects:

15.91 Because of the low dose of GM-CSF used and the slow release nature of the vaccine emulsion, side effects normally seen with systemic treatment doses of GM-CSF should not play a factor in this vaccination treatment. Expected side effects are related to the peptides and Montanide ISA-51. It is possible that the GM-CSF and CpG-7909 may potentiate the reaction seen at the injection site.

15.92 Dermatology/Skin: Injection site reaction, rare granuloma formation, possible development or worsening of pre-existing vitiligo, rash.

15.93 Hepatic: transient rises in liver transaminases.

15.94 Constitutional: Low-grade fever.

16.0 Statistical Considerations and Methodology

16.1 Study goals:

- **Primary goal:** to determine the safety and immunization efficacy of MUC1 and HER-2/neu peptide vaccines combined with CpG, GM-CSF or both, as immune adjuvants suspended in Montanide ISA-51.
- **Secondary goal:** to describe the impact of immunization on clinical outcomes in patients with MUC1 positive breast cancer.

16.2 The study design chosen for this proposal is a stratified randomized design. Toxicities will be carefully monitored and accrual will be suspended if 2 or more of the first six patients experience a grade 4 hematologic toxicity lasting for 5 or more days. In the event of at least

two patients experiencing immunologic toxicity $\geq$ grade 2 or any toxicity $\geq$ grade 3 accrual will be temporarily suspended for the given treatment arm.

- 16.3 Accrual: Fifteen patients with MUC1/HER-2 positive breast cancer with no evidence of disease will be randomized to each one of the 3 treatment schedules. The total number of eligible patients to be accrued will be 45. Patients will be allocated to each treatment schedule using a dynamic allocation procedure that balances the marginal distribution of type of dominant disease between treatment combinations. The expected accrual rate for this study is about 15-20 patients at Mayo Clinic Rochester and about 5-7 patients each at Mayo Clinic Scottsdale and Mayo Clinic Jacksonville per year. The study is expected to begin enrollment during May of 2005, and will accrue patients for approximately 2 years.

16.4 Study Endpoints:

16.41 Primary Endpoints

- 16.411 The immunologic parameters of interest are: (1) the percentage of CD4+ T cells, CD8+ T cells, B cells, monocytes, and dendritic cells in a patient's peripheral blood sample as estimated by flow cytometry with a panel of monoclonal antibodies and (2) the frequency of both peptide-specific IFN-gamma producing T cells and peptide-specific IL-5 producing T cells estimated by ELISPOT assays following *in vitro* stimulation with peptide-sensitized stimulator cells for the MUC1 and HER-2 peptides.
- 16.412 The number and severity of hematologic and non-hematologic toxicities reported using the NCI-CTC version 3.0 criteria

16.42 Secondary Endpoints

- 16.421 Disease-free survival is defined as the time from registration to the documentation of a first failure where a failure is the recurrence (REC) of breast cancer or a diagnosis of a second primary cancer (NEWP).
- 16.422 Overall survival is defined as the time from registration to death due to any cause.

16.43 Immunologic Parameters

- 16.431 All eligible patients who have completed one cycle of treatment are evaluable for the analysis of the immunologic parameters.
- 16.432 For each of the immunologic parameters, a plot of the parameter level against time will be constructed such that each patient is represented by a line connecting that patient's data points. These plots will enable visual assessment of patterns of change and variability within a parameter as well as a visual assessment of whether the immunologic parameters peak or fall at similar time points.
- 16.433 Also, for each of the immunologic parameters, a plot of the percent change from pre-treatment levels against time will be constructed such that each patient is represented by a line connecting that patient's data points. These plots will enable visual assessment of time trends within a parameter controlling for pretreatment levels.

16.44 Adverse Events

- 16.441 All eligible patients who received at least one vaccination are evaluable for toxicity.
- 16.442 The frequency of those hematologic and non-hematologic toxicities considered at least possibly related to treatment will be tabulated by severity.
- 16.443 The circumstances surrounding any treatment-related death will be reported.
- 16.444 As this is a pilot study, no formal hypothesis tests comparing treatment schedules are planned. An immunization strategy will be considered for further testing if at least 70% patients treated with that strategy had a ≥ 2 -fold increase in the percentage of vaccine-peptide specific CD8+ T cells during the course of treatment, with tolerable toxicity.
- 16.445 The principal investigator and study statistician will review the study every 3 months to identify potential accrual, toxicity, or endpoint problems. In addition, this study will be monitored by the Cancer Center Data Safety Monitoring Board. All patient related clinical data will be entered and maintained online, with reports generated as needed to comply with reporting guidelines.
- 16.446 It should be noted that representatives of the U.S. Army Medical Research and Merial Command are eligible to review research records as a part of their responsibility to protect human subjects in research.
- 16.447 If the protocol requires any modifications, deviations or termination prior to completion, all administrative activities will comply with the Protocol Review and Monitoring System of the Mayo Clinic Comprehensive Cancer Center. In addition, all local IRB communications, including deviations from protocol, will be forwarded to the Department of Defense HSRRB, upon local approval.

16.45 Inclusion of Minorities

This study will be available to all eligible patients, regardless of race or ethnic group. There is no information currently available regarding differential agent effects in subjects defined by gender, race, or ethnicity. The planned analyses will, as always, look for differences in treatment effect based on racial groupings. The sample sizes of this pilot study, however, are not sufficient to provide power for such subset analyses.

To predict the characteristics of patients likely to enroll in this trial we have reviewed registration to (non-North American Breast Cancer Intergroup) NCCTG breast cancer clinical trials by race. This revealed that roughly 3% of patients registered into cancer trials during the past five years could be classified as minorities, which would suggest that only 1 or 2 patients in the study sample are expected to be classified as minorities. This small sample precludes the possibility of a separate subset analysis beyond simple inspection of results for the 1 or 2 minority patients.

17.0 Pathology Considerations for Quality Control

17.1 There will be a central review of tumor tissues stained for MUC-1 and HER-2/neu

17.11 Describe materials to be submitted.

Pathology Reporting Form
Surgical Pathology and Operative Report
All diagnostic slides

Slides should be placed in appropriate slide container and labeled with the protocol number, study patient number, and patient initials.

1 8.0 Records and Data Entry Procedures

18.1 Data Entry Timetable

Forms	Active-Monitoring Phase (Compliance with Test Schedule)			Event-Monitoring Phase ¹ (Completion of Active-Monitoring Phase)				At Each Occurrence			
	Initial Material	Follow-up material		q.3 months until PROG	At PROG	After PROG q. 3 mos.	Death	ADR/ AER	New Primary	Grade 4 or 5 Non-AER Reportable Events/ Hospitalization	Late Adverse Event
	≤2 weeks after registration	At each evaluation	At end of treatment								
On-Study Form	X										
Specimen Submission Form ²	X										
Baseline Adverse Events/ Symptoms	X										
Measurement Form	X	X	X								
Evaluation/Treatment Form		X	X								
Evaluation/Observation Form		X ⁵									
DTH Laboratory Form ³	X										
Interval Laboratory Form ⁴	X										
Nadir/Adverse Event Form		X	X								
End of Active Treatment Form			X								
Event-Monitoring Form			X	X	X	X	X		X		X
Concurrent Treatment Log	X	X	X								
ADR/AER (See Section 10.0)								X			
Secondary AML/MDS Report Form (See Section 10.0)								X			
Grade 4 or 5 Non-AER Reportable Events/ Hospitalization Form (See Section 10.0)										X	

1. If a patient is still alive after 2 years after registration, no further follow-up is required.
2. Research blood samples will be performed before registration as well as prior to **cycles 3, 5 and 6** of therapy as well as every other cycle of long-term follow-up **starting at 3 months** after completion of Rx up to two years.
3. At baseline and prior to cycle 6 only.
4. At baseline, prior to each subsequent treatment and at 4 weeks after last treatment.
5. Complete at each evaluation during Observation (see Section 4.0).

19.0 Budget Considerations

19.1 Costs charged to patient: routine clinical care.

19.2 Tests and procedures to be research funded: HLA typing, tumor typing, DTH testing and serum pregnancy tests. Funding will be provided by the Department of Defense (DOD).

20.0 References

1. Morton, D.L., E.C. Hsueh, R. Essner, L.J. Foshag, S.J. O'Day, A. Bilchik, R.K. Gupta, D.S. Hoon, M. Ravindranath, J.A. Nizze, G. Gammon, L.A. Wanek, H.J. Wang, and R.M. Elashoff, Prolonged survival of patients receiving active immunotherapy with Canvaxin therapeutic polyvalent vaccine after complete resection of melanoma metastatic to regional lymph nodes. (2002) *Ann Surg.* 236:438-48; discussion 448-9.
2. Apostolopoulos, V., G.A. Pietersz, and I.F. McKenzie, MUC1 and breast cancer. (1999) *Curr Opin Mol Ther.* 1:98-103.
3. Disis, M.L., T.A. Gooley, K. Rinn, D. Davis, M. Piepkorn, M.A. Cheever, K.L. Knutson, and K. Schiffman, Generation of T-cell immunity to the HER-2/neu protein after active immunization with HER-2/neu peptide-based vaccines. (2002) *J Clin Oncol.* 20:2624-32.
4. Chomez, P., O. De Backer, M. Bertrand, E. De Plaen, T. Boon, and S. Lucas, An overview of the MAGE gene family with the identification of all human members of the family. (2001) *Cancer Res.* 61:5544-51.
5. Schlom, J., J. Kantor, S. Abrams, K.Y. Tsang, D. Panicali, and J.M. Hamilton, Strategies for the development of recombinant vaccines for the immunotherapy of breast cancer. (1996) *Breast Cancer Res Treat.* 38:27-39.
6. Townsend, A. and H. Bodmer, Antigen recognition by class I-restricted T lymphocytes. (1989) *Annu Rev Immunol.* 7:601-24.
7. Tsai, V., I. Kawashima, E. Keogh, K. Daly, A. Sette, and E. Celis, In vitro immunization and expansion of antigen-specific cytotoxic T lymphocytes for adoptive immunotherapy using peptide-pulsed dendritic cells. (1998) *Crit Rev Immunol.* 18:65-75.
8. Tsai, V., S. Southwood, J. Sidney, K. Sakaguchi, Y. Kawakami, E. Appella, A. Sette, and E. Celis, Identification of subdominant CTL epitopes of the GP100 melanoma-associated tumor antigen by primary in vitro immunization with peptide-pulsed dendritic cells. (1997) *J Immunol.* 158:1796-802.
9. Nestle, F.O., S. Alijagic, M. Gilliet, Y. Sun, S. Grabbe, R. Dummer, G. Burg, and D. Schadendorf, Vaccination of melanoma patients with peptide- or tumor lysate-pulsed dendritic cells. (1998) *Nat Med.* 4:328-32.
10. Cerundolo, V., Use of major histocompatibility complex class I tetramers to monitor tumor-specific cytotoxic T lymphocyte response in melanoma patients. (2000) *Cancer Chemother Pharmacol.* 46 Suppl:S83-5.
11. Altman, J.D., P.A. Moss, P.J. Goulder, D.H. Barouch, M.G. McHeyzer-Williams, J.I. Bell, A.J. McMichael, and M.M. Davis, Phenotypic analysis of antigen-specific T lymphocytes. (1996) *Science.* 274:94-6.
12. Amoscato, A.A., D.A. Prenovitz, and M.T. Lotze, Rapid extracellular degradation of synthetic class I peptides by human dendritic cells. (1998) *J Immunol.* 161:4023-32.
13. Nair, S.K., D. Snyder, B.T. Rouse, and E. Gilboa, Regression of tumors in mice vaccinated with professional antigen-presenting cells pulsed with tumor extracts. (1997) *Int J Cancer.* 70:706-15.

14. Zotter, S., P.C. Hageman, A. Lossnitzer, W.J. Mooi, and J. Hilgers, Tissue and tumor distribution of human polymorphic epithelial mucin. (1988) *Cancer Reviews*. 11-12:55-101.
15. Girling, A., J. Bartkova, J. Burchell, S. Gendler, C. Gillet, and J. Taylor-Papadimitriou, A core protein epitope of the polymorphic epithelial mucin detected by the monoclonal antibody SM-3 is selectively exposed in a range of primary carcinomas. (1989) *Int J Cancer*. 43:1072-1076.
16. Croce, M.V., M.T. Isla-Larrain, C.E. Rua, M.E. Rabassa, S.J. Gendler, and A. Segal-Eiras, Patterns of MUC1 tissue expression defined by an anti-MUC1 cytoplasmic tail monoclonal antibody in breast cancer. (2003) *J Histochem Cytochem*. 51:781-8.
17. Treon, S.P., J.A. Mollick, M. Urashima, G. Teoh, D. Chauhan, A. Ogata, N. Raje, J.H.M. Hilgers, L. Nadler, A.R. Belch, L.M. Pilarski, and K.C. Anderson, MUC1 core protein is expressed on multiple myeloma cells and is induced by dexamethasone. (1999) *Blood*. 93:1287-1298.
18. Brossart, P., A. Schneider, P. Dill, T. Schammann, F. Grunebach, S. Wirths, L. Kanz, H.J. Buhring, and W. Brugger, The epithelial tumor antigen MUC1 is expressed in hematological malignancies and is recognized by MUC1-specific cytotoxic T-lymphocytes. (2001) *Cancer Res*. 61:6846-50.
19. Gendler, S.J., MUC1, the renaissance molecule. (2001) *J Mammary Gland Biol Neoplasia*. 6:339-53.
20. Barnd, D.L., M.S. Lan, R.S. Metzgar, and O.J. Finn, Specific, major histocompatibility complex-unrestricted recognition of tumor-associated mucins by human cytotoxic T cells. (1989) *Proc Natl Acad Sci U S A*. 86:7159-63.
21. Finn, O.J., K.R. Jerome, R.A. Henderson, G. Pecher, N. Domenech, J. Magarian-Blander, and S.M. Barratt-Boyes, MUC-1 epithelial tumor mucin-based immunity and cancer vaccines. (1995) *Immunological Reviews*. 145:61-89.
22. Takahashi, T., Y. Makiguchi, Y. Hinoda, H. Kakiuchi, N. Nakagawa, K. Imai, and A. Yachi, Expression of MUC1 on myeloma cells and induction of HLA-unrestricted CTL against MUC1 from a multiple myeloma patient. (1994) *J Immunol*. 153:2102-9.
23. Noto, H., T. Takahashi, Y. Makiguchi, T. Hayashi, Y. Hinoda, and K. Imai, Cytotoxic T lymphocytes derived from bone marrow mononuclear cells of multiple myeloma patients recognize an underglycosylated form of MUC1 mucin. (1997) *Int Immunol*. 9:791-8.
24. Domenech, N., R.A. Henderson, and O.J. Finn, Identification of an HLA-A11-restricted epitope from the tandem repeat domain of the epithelial tumor antigen mucin. (1995) *J Immunol*. 155:4766-74.
25. Agrawal, B., M.A. Reddish, and B.M. Longenecker, In vitro induction of MUC-1 peptide-specific type 1 T lymphocyte and cytotoxic T lymphocyte responses from healthy multiparous donors. (1996) *J Immunol*. 157:2089-95.
26. Apostolopoulos, V., J.S. Haurum, and I.F.C. McKenzie, Muc1 Peptide Epitopes Associated With Five Different H-2 Class I Molecules. (1997) *Eur J Immunol*. 27:2579-2587.
27. Apostolopoulos, V., V. Karanikas, J.S. Haurum, and I.F. McKenzie, Induction of HLA-A2-restricted CTLs to the mucin 1 human breast cancer antigen. (1997) *J Immunol*. 159:5211-8.

28. Reddish, M., G.D. MacLean, R.R. Koganty, J. Kan-Mitchell, V. Jones, M.S. Mitchell, and B.M. Longenecker, Anti-MUC1 class I restricted CTLs in metastatic breast cancer patients immunized with a synthetic MUC1 peptide. (1998) *Int J Cancer*. 76:817-23.
29. Mukherjee, P., A.R. Ginardi, C.S. Madsen, C.J. Sterner, M.C. Adriance, M.J. Tevethia, and S.J. Gendler, Mice with spontaneous pancreatic cancer naturally develop MUC1-specific CTLs that eradicate tumors when adoptively transferred. (2000) *J Immunol*. 165:3451-3460.
30. Mukherjee, P., C.S. Madsen, A.R. Ginardi, T.L. Tinder, F. Jacobs, J. Parker, B. Agrawal, B.M. Longenecker, and S.J. Gendler, Mucin 1-specific immunotherapy in a mouse model of spontaneous breast cancer. (2003) *J Immunother*. 26:47-62.
31. Mukherjee, P., A.R. Ginardi, T.L. Tinder, C.J. Sterner, and S.J. Gendler, MUC1-specific CTLs eradicate tumors when adoptively transferred in vivo. (2001) *Clin Can Res*. 7:848s-855s.
32. Mukherjee, P., A.R. Ginardi, C.S. Madsen, T.L. Tinder, F. Jacobs, J. Parker, B. Agrawal, B.M. Longenecker, and S.J. Gendler, MUC1-specific CTLs are non-functional within a pancreatic tumor microenvironment. (2003) *Glycoconj J*. 18:931-942.
33. Brossart, P., K.S. Heinrich, G. Stuhler, L. Behnke, V.L. Reichardt, S. Stevanovic, A. Muhm, H.G. Rammensee, L. Kanz, and W. Brugger, Identification of HLA-A2-restricted T-cell epitopes derived from the MUC1 tumor antigen for broadly applicable vaccine therapies. (1999) *Blood*. 93:4309-17.
34. Slamon, D.J., W. Godolphin, L.A. Jones, J.A. Holt, S.G. Wong, D.E. Keith, W.J. Levin, S.G. Stuart, J. Udove, A. Ullrich, and et al., Studies of the HER-2/neu proto-oncogene in human breast and ovarian cancer. (1989) *Science*. 244:707-12.
35. Yokota, J., T. Yamamoto, K. Toyoshima, M. Terada, T. Sugimura, H. Battifora, and M.J. Cline, Amplification of c-erbB-2 oncogene in human adenocarcinomas in vivo. (1986) *Lancet*. 1:765-7.
36. Clark, G.M. and W.L. McGuire, Follow-up study of HER-2/neu amplification in primary breast cancer. (1991) *Cancer Res*. 51:944-8.
37. Revillion, F., J. Bonnetterre, and J.P. Peyrat, ERBB2 oncogene in human breast cancer and its clinical significance. (1998) *Eur J Cancer*. 34:791-808.
38. Disis, M.L., K.L. Knutson, K. Schiffman, K. Rinn, and D.G. McNeel, Pre-existent immunity to the HER-2/neu oncogenic protein in patients with HER-2/neu overexpressing breast and ovarian cancer. (2000) *Breast Cancer Res Treat*. 62:245-52.
39. Disis, M.L., S.M. Pupa, J.R. Gralow, R. Dittadi, S. Menard, and M.A. Cheever, High-Titer Her-2/Neu Protein-Specific Antibody Can Be Detected In Patients With Early-Stage Breast Cancer. (1997) *Journal of Clinical Oncology*. 15:3363-3367.
40. Kawashima, I., S.J. Hudson, V. Tsai, S. Southwood, K. Takesako, E. Appella, A. Sette, and E. Celis, The multi-epitope approach for immunotherapy for cancer: identification of several CTL epitopes from various tumor-associated antigens expressed on solid epithelial tumors. (1998) *Hum Immunol*. 59:1-14.
41. Vanderlugt, C.L. and S.D. Miller, Epitope spreading in immune-mediated diseases: implications for immunotherapy. (2002) *Nat Rev Immunol*. 2:85-95.

42. Butterfield, L.H., A. Ribas, V.B. Disette, S.N. Amarnani, H.T. Vu, D. Oseguera, H.J. Wang, R.M. Elashoff, W.H. McBride, B. Mukherji, A.J. Cochran, J.A. Glaspy, and J.S. Economou, Determinant spreading associated with clinical response in dendritic cell-based immunotherapy for malignant melanoma. (2003) *Clin Cancer Res.* 9:998-1008.
43. McRae, B.L., C.L. Vanderlugt, M.C. Dal Canto, and S.D. Miller, Functional evidence for epitope spreading in the relapsing pathology of experimental autoimmune encephalomyelitis. (1995) *J Exp Med.* 182:75-85.
44. Vanderlugt, C.L., K.L. Neville, K.M. Nikceovich, T.N. Eagar, J.A. Bluestone, and S.D. Miller, Pathologic role and temporal appearance of newly emerging autoepitopes in relapsing experimental autoimmune encephalomyelitis. (2000) *J Immunol.* 164:670-8.
45. Swain, S.L., Regulation of the generation and maintenance of T-cell memory: a direct, default pathway from effectors to memory cells. (2003) *Microbes Infect.* 5:213-9.
46. Schoenberger, S.P., R.E. Toes, E.I. van der Voort, R. Offringa, and C.J. Melief, T-cell help for cytotoxic T lymphocytes is mediated by CD40-CD40L interactions. (1998) *Nature.* 393:480-3.
47. Ridge, J.P., F. Di Rosa, and P. Matzinger, A conditioned dendritic cell can be a temporal bridge between a CD4+ T- helper and a T-killer cell [see comments]. (1998) *Nature.* 393:474-8.
48. Bennett, S.R., F.R. Carbone, F. Karamalis, R.A. Flavell, J.F. Miller, and W.R. Heath, Help for cytotoxic-T-cell responses is mediated by CD40 signalling. (1998) *Nature.* 393:478-80.
49. Riddell, S.R., K.S. Watanabe, J.M. Goodrich, C.R. Li, M.E. Agha, and P.D. Greenberg, Restoration of viral immunity in immunodeficient humans by the adoptive transfer of T cell clones. (1992) *Science.* 257:238-41.
50. Heslop, H.E., C.Y. Ng, C. Li, C.A. Smith, S.K. Loftin, R.A. Krance, M.K. Brenner, and C.M. Rooney, Long-term restoration of immunity against Epstein-Barr virus infection by adoptive transfer of gene-modified virus-specific T lymphocytes. (1996) *Nat Med.* 2:551-5.
51. Mailliard, R.B., S. Egawa, Q. Cai, A. Kalinska, S.N. Bykovskaya, M.T. Lotze, M.L. Kapsenberg, W.J. Storkus, and P. Kalinski, Complementary dendritic cell-activating function of CD8+ and CD4+ T cells: helper role of CD8+ T cells in the development of T helper type 1 responses. (2002) *J Exp Med.* 195:473-83.
52. Disis, M.L., E. Calenoff, G. McLaughlin, A.E. Murphy, W. Chen, B. Groner, M. Jeschke, N. Lydon, E. McGlynn, R.B. Livingston, and et al., Existent T-cell and antibody immunity to HER-2/neu protein in patients with breast cancer. (1994) *Cancer Res.* 54:16-20.
53. Disis, M.L., H. Bernhard, F.M. Shiota, S.L. Hand, J.R. Gralow, E.S. Huseby, S. Gillis, and M.A. Cheever, Granulocyte-macrophage colony-stimulating factor: an effective adjuvant for protein and peptide-based vaccines. (1996) *Blood.* 88:202-10.
54. Cheever, M.A., M.L. Disis, H. Bernhard, J.R. Gralow, S.L. Hand, E.S. Huseby, H.L. Qin, M. Takahashi, and W. Chen, Immunity to oncogenic proteins. (1995) *Immunol Rev.* 145:33-59.
55. Disis, M.L. and M.A. Cheever, HER-2/neu protein: a target for antigen-specific immunotherapy of human cancer. (1997) *Adv Cancer Res.* 71:343-71.

56. Tuttle, T.M., B.W. Anderson, W.E. Thompson, J.E. Lee, A. Sahin, T.L. Smith, K.H. Grabstein, J.T. Wharton, C.G. Ioannides, and J.L. Murray, Proliferative and cytokine responses to class II HER-2/neu-associated peptides in breast cancer patients. (1998) *Clin Cancer Res.* 4:2015-24.
57. Fisk, B., J.M. Hudson, J. Kavanagh, J.T. Wharton, J.L. Murray, C.G. Ioannides, and A.P. Kudelka, Existent proliferative responses of peripheral blood mononuclear cells from healthy donors and ovarian cancer patients to HER-2 peptides. (1997) *Anticancer Res.* 17:45-53.
58. Kobayashi, H., M. Wood, Y. Song, E. Appella, and E. Celis, Defining promiscuous MHC class II helper T-cell epitopes for the HER2/neu tumor antigen. (2000) *Cancer Res.* 60:5228-36.
59. Jones, T., A. Stern, and R. Lin, Potential role of granulocyte-macrophage colony-stimulating factor as vaccine adjuvant. (1994) *Eur J Clin Microbiol Infect Dis.* 13:S47-53.
60. Jager, E., M. Ringhoffer, H.P. Dienes, M. Arand, J. Karbach, D. Jager, C. Ilseemann, M. Hagedorn, F. Oesch, and A. Knuth, Granulocyte-macrophage-colony-stimulating factor enhances immune responses to melanoma-associated peptides in vivo. (1996) *Int J Cancer.* 67:54-62.
61. Fagerberg, J., Granulocyte-macrophage colony-stimulating factor as an adjuvant in tumor immunotherapy. (1996) *Med Oncol.* 13:155-60.
62. Carlsson, T. and J. Struve, Granulocyte-macrophage colony-stimulating factor given as an adjuvant to persons not responding to hepatitis B vaccine [letter]. (1997) *Infection.* 25:129.
63. Pardoll, D.M., Paracrine cytokine adjuvants in cancer immunotherapy. (1995) *Annu Rev Immunol.* 13:399-415.
64. Golumbek, P.T., R. Azhari, E.M. Jaffee, H.I. Levitsky, A. Lazenby, K. Leong, and D.M. Pardoll, Controlled release, biodegradable cytokine depots: a new approach in cancer vaccine design. (1993) *Cancer Res.* 53:5841-4.
65. Kawakami, Y., P.F. Robbins, X. Wang, J.P. Tupesis, M.R. Parkhurst, X. Kang, K. Sakaguchi, E. Appella, and S.A. Rosenberg, Identification of new melanoma epitopes on melanosomal proteins recognized by tumor infiltrating T lymphocytes restricted by HLA-A1, -A2, and -A3 alleles. (1998) *J Immunol.* 161:6985-92.
66. Salgaller, M.L., F.M. Marincola, J.N. Cormier, and S.A. Rosenberg, Immunization against epitopes in the human melanoma antigen gp100 following patient immunization with synthetic peptides. (1996) *Cancer Res.* 56:4749-57.
67. Slingluff, C.L., Jr., G.R. Petroni, G.V. Yamshchikov, D.L. Barnd, S. Eastham, H. Galavotti, J.W. Patterson, D.H. Deacon, S. Hibbitts, D. Teates, P.Y. Neese, W.W. Grosh, K.A. Chianese-Bullock, E.M. Woodson, C.J. Wiernasz, P. Merrill, J. Gibson, M. Ross, and V.H. Engelhard, Clinical and immunologic results of a randomized phase II trial of vaccination using four melanoma peptides either administered in granulocyte-macrophage colony-stimulating factor in adjuvant or pulsed on dendritic cells. (2003) *J Clin Oncol.* 21:4016-26.
68. Miconnet, I., S. Koenig, D. Speiser, A. Krieg, P. Guillaume, J.C. Cerottini, and P. Romero, CpG are efficient adjuvants for specific CTL induction against tumor antigen-derived peptide. (2002) *J Immunol.* 168:1212-8.

69. Maletto, B., A. Ropolo, V. Moron, and M.C. Pistoiresi-Palencia, CpG-DNA stimulates cellular and humoral immunity and promotes Th1 differentiation in aged BALB/c mice. (2002) *J Leukoc Biol.* 72:447-54.
70. Sa, H., B.R. Mei, Y.H. Wang, and D.J. Qian, [Diagnostic value of integral of dorsal acoustic scattering for acute viral myocarditis]. (2003) *Zhonghua Er Ke Za Zhi.* 41:228-9.
71. Celis, E., V. Tsai, C. Crimi, R. DeMars, P.A. Wentworth, R.W. Chesnut, H.M. Grey, A. Sette, and H.M. Serra, Induction of anti-tumor cytotoxic T lymphocytes in normal humans using primary cultures and synthetic peptide epitopes. (1994) *Proc Natl Acad Sci U S A.* 91:2105-9.
72. Southwood, S., J. Sidney, A. Kondo, M.F. del Guercio, E. Appella, S. Hoffman, R.T. Kubo, R.W. Chesnut, H.M. Grey, and A. Sette, Several common HLA-DR types share largely overlapping peptide binding repertoires. (1998) *J Immunol.* 160:3363-73.
73. Ramanathan, R.K., K.M. Lee, J. McKolanis, E. Hitbold, W. Schraut, A.J. Moser, E. Warnick, T. Whiteside, J. Osborne, H. Kim, R. Day, M. Troetschel, and O.J. Finn, Phase I study of a MUC1 vaccine composed of different doses of MUC1 peptide with SB-AS2 adjuvant in resected and locally advanced pancreatic cancer. (2005) *Cancer Immunol Immunother.* 54:254-64.
74. Bennouna, J., A. Hildesheim, K. Chikamatsu, W. Gooding, W.J. Storkus, and T.L. Whiteside, Application of IL-5 ELISPOT assays to quantification of antigen-specific T helper responses. (2002) *J Immunol Methods.* 261:145-56.
75. Jager, E., Y. Nagata, S. Gnjjatic, H. Wada, E. Stockert, J. Karbach, P.R. Dunbar, S.Y. Lee, A. Jungbluth, D. Jager, M. Arand, G. Ritter, V. Cerundolo, B. Dupont, Y.T. Chen, L.J. Old, and A. Knuth, Monitoring CD8 T cell responses to NY-ESO-1: correlation of humoral and cellular immune responses. (2000) *Proc Natl Acad Sci U S A.* 97:4760-5.
76. McMichael, A.J. and C.A. O'Callaghan, A new look at T cells. (1998) *J Exp Med.* 187:1367-71.
77. Speiser, D.E., M.J. Pittet, P. Guillaume, N. Lubenow, E. Hoffman, J.C. Cerottini, and P. Romero, Ex vivo analysis of human antigen-specific CD8+ T-cell responses: quality assessment of fluorescent HLA-A2 multimer and interferon-gamma ELISPOT assays for patient immune monitoring. (2004) *J Immunother.* 27:298-308.

Appendix I

ECOG PERFORMANCE STATUS**Grade**

- | | |
|---|---|
| 0 | Fully active, able to carry on all pre-disease activities without restriction (Karnofsky 90-100). |
| 1 | Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work (Karnofsky 70-80). |
| 2 | Ambulatory and capable of all self-care, but unable to carry out any work activities. Up and about more than 50 percent of waking hours (Karnofsky 50-60). |
| 3 | Capable of only limited self-care, confined to bed or chair 50 percent or more of waking hours (Karnofsky 30-40). |
| 4 | Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair (Karnofsky 10-20). |
| 5 | Dead |

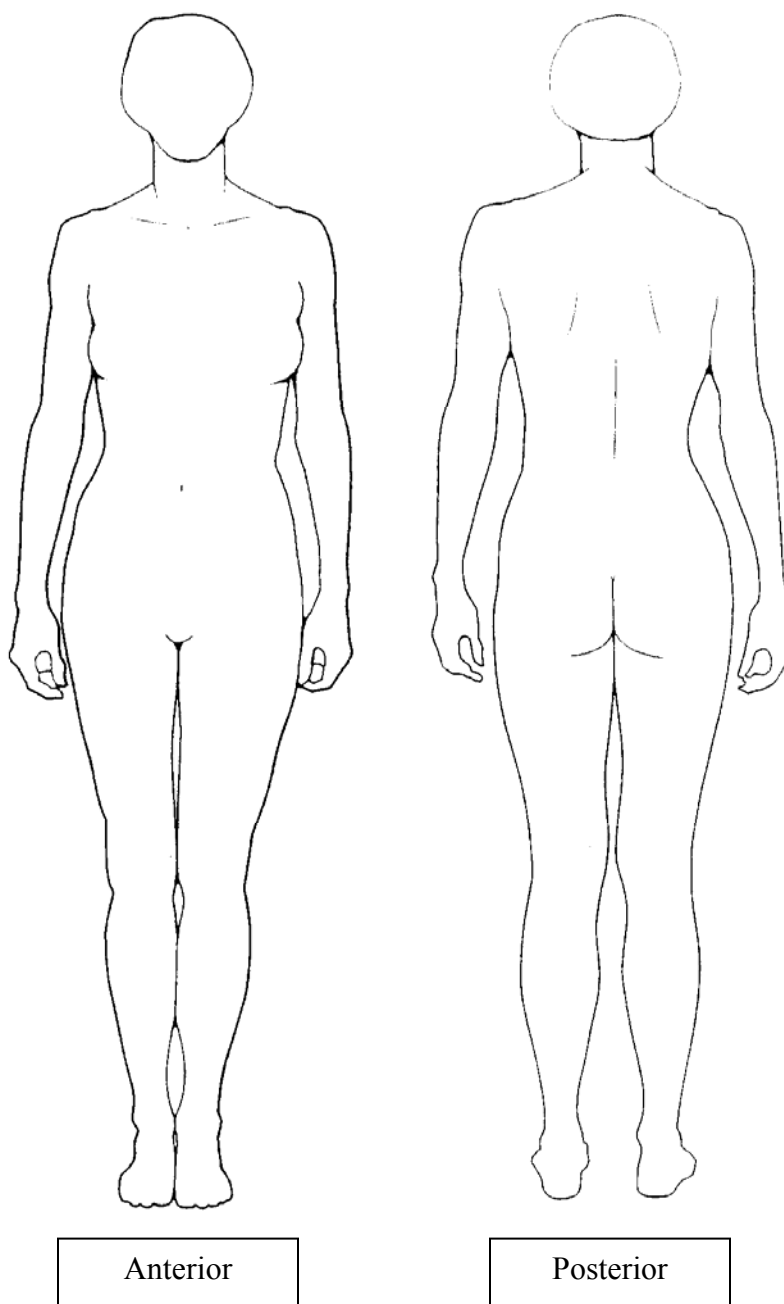
Appendix II

Site Injection Record

Protocol #: _____ Patient #: _____ Patient Initials: _____
F M L

Please indicate on the diagrams below all sites of vaccine injection (circle).

Date of determination: / /
 M D Y



ROUGH DRAFT**Not to be used with participants**

TITLE: MC0338, “MUC1/HER-2/neu Peptide Based Immunotherapeutic Vaccines for Breast Adenocarcinomas”

IRB #: 782-05 00

RESEARCHER: Dr. S. N. Markovic and colleagues.

PROTOCOL LAST APPROVED BY INSTITUTIONAL REVIEW BOARD:

THIS FORM APPROVED:

This is an important form. Please read it carefully. It tells you what you need to know about this research study. If you agree to take part in this study, you need to sign this form. Your signature means that you have been told about the study and what the risks are. Your signature on this form also means that you want to take part in this study.

Why is this research study being done?

We are inviting you to participate in this study because of your history of resected breast cancer for which you have already received standard therapy and have no evidence of relapse. Your good overall health and no other history of cancer make it possible for us to offer you participation on this clinical study.

This study is being done to evaluate three different preparations of a breast cancer vaccine to stimulate anti-cancer (T-cell) immune responses and any side effects associated with these vaccinations. The breast cancer vaccine (MUC-1/HER-2/neu peptides) will be combined with one of two immune boosting agents (CpG or GM-CSF) or with immune boosting agents together. These immune boosting agents are believed to be able to make the vaccine more effective. Whether or not this will protect you from the breast cancer is still unknown.

The breast cancer vaccine and one of the immune boosting agents (CpG) have not been approved by the Food and Drug Administration (FDA) for commercial use; however, FDA has permitted their use in this research study. GM-CSF is commercially available for use in clinical practice. Laboratory experiments have shown that both of these immune boosting agents are able to make the vaccines more effective in generating an immune response. In laboratory animals, both agents are very effective in boosting anti-tumor immune responses. However, in clinical trials, neither GM-CSF or CpG has shown effects against cancer, but they both seem to improve the effectiveness of some vaccines. One of the goals of this study is to determine if the unique application of GM-

CSF and/or CpG in this study, based on our laboratory data, will make them more likely to improve anti-vaccine immunity.

This study is sponsored by the Department of Defense.

How many people will take part in this research study?

The plan is to have up to 45 people take part in this study at Mayo Clinic Rochester, Jacksonville, and Arizona. Up to 60 people may be screened to find enough eligible people to begin the study.

What will happen in this research study?

Before you enter the study, you will have a physical examination and blood tests to make sure that you qualify to take part in this study. About 6 tablespoons of blood will be taken for testing.

If you qualify to take part, you will have blood taken for immunologic testing (to see how your immune system is working) for the study as well as a skin test (allergy test). You will then be randomly assigned (as in the toss of the dice) to be treated with one of three breast cancer vaccines combinations.

Each vaccination will consist of one or two subcutaneous (under the skin) injections of about one half teaspoonful (2ml) of the cancer vaccine and boosting agent combination. The vaccine will be given with Montanide ISA 51, which is an oil that is mixed with the vaccine so that the vaccine can be released into the body slowly. The vaccine will be injected under the skin in areas where there has been no surgery. Usual areas of vaccination include the skin of the upper arms and legs. Vaccinations will be repeated every 4 weeks for 6 months. Before every vaccination, you will be seen by your doctor, examined and about 6 tablespoons of blood will be collected to study the development of the anti-cancer immune response. Skin tests will be done prior to vaccinations #6 (see the following table). Evaluations for the cancer (body scans) will be done if and when your doctor thinks it is necessary.

Pre-Study	• Routine¹ and research blood tests • Cancer evaluation (scans) • Physical examination • Skin test (Mayo Clinic Rochester, only)
Vaccination #1 (month 1)	• Vaccine treatment
Vaccination #2 (month 2)	• Routine blood test collection • Physical examination • Vaccine treatment
Vaccination #3 (month 3)	• Routine and research blood test collection • Physical examination • Cancer evaluation (scans) • Vaccine treatment
Vaccination #4 (month 4)	• Routine blood test collection • Physical examination • Vaccine treatment
Vaccination #5 (month 5)	• Routine and research blood test collection • Physical examination • Vaccine treatment
Vaccination #6 (month 6)	• Routine and research blood test collection • Physical examination • Cancer evaluation (scans) • Vaccine treatment • Skin test (Mayo Clinic Rochester, only)
Every 3 months after the first six months until 5 years after first vaccination	• Physical examination • Routine blood tests • Cancer evaluation (scans)
Every 3 months after the first six months until 2 years after first vaccination	• Research bloods

1. Routine blood tests include: complete blood count and blood chemistries.

How long will I be in this research study?

You will be on the study for 6 months, and you will be seen in follow-up until 5 years after your first vaccination.

Are there reasons I might leave this research study early?

Taking part in this research study is your decision. You may decide to stop at any time. You should tell the study doctor if you decide to stop and you will be advised whether any additional tests may need to be done for your safety.

In addition, the investigators or Mayo may stop you from taking part in this study at any time if it is in your best interest, if you do not follow the study rules, or if the study is stopped.

Will any biological sample(s) be stored and used for research in the future?

No. Your samples will be used as described for this study, and then will be destroyed.

What are the risks of this research study?

While you are taking part in this study, you are at risk for the following side effects. You should talk to your study doctor and/or your medical doctor about these side effects. There also may be other side effects that are not known. Other drugs may be given to lessen side effects. Many side effects go away shortly after the vaccine treatments are stopped, but in some cases side effects can be serious, long lasting, or may never go away. The side effects can be mild or can lead to death.

You will be closely watched by the study team for any side effects. If side effects happen, the study team will take the necessary steps to treat them. This may include stopping the medication and/or stopping the study.

If any new side effects are found as the study continues, you will be notified.

The possible side effects of the following: MUC-1/HER-2/neu, breast cancer vaccine, Montanide ISA 51 (the oil), CpG (immune booster), and GM-CSF (immune booster) include:

Common:

- Injection site reactions: discomfort, rash, redness, firmness, warmth, bleeding, tenderness to touch, numbness, tingling, itching.
- Systemic reactions: skin rash, itching, sweating, muscle aches, joint aches, fatigue.

Rare:

- Injection site reactions: pain, ulceration.
- Systemic reactions: low blood counts, difficulty breathing, heart problems, blood clots, seizures, infection, kidney and liver problems, headache, stomach pain, cough.

Although many of these reactions are similar to vaccines that you may have received in the past, the listed side effects that could happen might be more severe. However, we expect that all of these reactions will be very mild. Treatment for these reactions will depend on the type and severity of the reaction. Treatments will be directed at suppressing the immune reaction to the vaccine and may range from mild anti-allergic/anti-inflammatory treatments (for example topical hydrocortisone or Motrin) to more powerful anti-inflammatory therapy including corticosteroids. If severe reactions happen, they may require hospitalization and possibly even minor surgery (severe local

skin reactions) These are highly unlikely. The cost of these treatments for reactions will depend on the specific requirements and will vary widely.

When GM-CSF has been given at higher doses as a daily injection the following side effects have also been reported: diarrhea, general weakness, fever, chills, nausea, vomiting, loss of appetite, headache, pain in the bones, joints and muscles. Most of the symptoms were mild or moderate in severity and were less after taking acetaminophen (Tylenol). Other side effects which happened very rarely were: difficulty breathing, rapid or irregular heart beat or other heart problems, swelling. Even less common, reported side effects have been the following: 1) increased white cells in the lungs with breathing problems; 2) a syndrome of shortness of breath, low oxygen in the blood, redness in the skin, low blood pressure and dizziness when you stand up or a loss of balance and partial loss of consciousness; 3) serious allergic reactions (like a very severe asthma attack); 4) blood clotting; 5) facial flushing; 6) kidney or liver problems; 7) worsening of fluid accumulation in the arms, legs, lungs or around the heart which may cause problems with breathing or heart failure; 8) patients with heart, lung, kidney or liver problems may have worsening of their symptoms following GM-CSF; and 9) nerve toxicity (weakness, shooting pains, numbness, increased sensitivity to touch, loss of balance, dizziness)

Skin testing: The risks and discomfort of skin testing are minimal and usually limited to bleeding, bruising, or infection at the injection site.

Blood draws: A blood drawing may cause slight pain and a small risk of bleeding, bruising, or infection at the injection site.

There is not enough medical information to know what the risks might be to a breast-fed infant or to an unborn child of a woman who takes part in this study. Women who can become pregnant must use one of these birth control plans during this study: diaphragm, birth control pills, injections, intrauterine device (IUD), surgical sterilization, under the skin implants, abstinence. Another choice is for your sexual partner to use appropriate forms of contraception. Breast-feeding mothers must stop breast-feeding to take part in this study. Women who can become pregnant must have a pregnancy test before taking part in this study. For the pregnancy test, blood will be taken from a vein in your arm with a needle within 7 days before you enter the study. You will be told the results of the pregnancy test. If the pregnancy test is positive, you will not be able to take part in the study.

This study may involve risks to you (or to an embryo or fetus if you become pregnant) that are currently unforeseeable.

There may be other risks with the combination of drugs/vaccine which we are not yet aware of.

Are there benefits to taking part in this research study?

This study may not make your health better. However, the information learned may benefit future patients with breast cancer.

What other choices do I have if I don't take part in this research study?

You do not have to be in this study to receive care for your condition. Your other choices may include participation on other clinical studies or no other care at all, but you will have regular appointments with your doctor who will check your condition. You should talk to your doctor about your choices before you decide if you will take part in this study.

Will I need to pay for the tests and procedures?

You will not need to pay for any tests and exams that are done just for this research study, including the research blood tests, skin tests and office visits done only for this research study. However, you and/or your health plan will need to pay for all other tests and procedures that are part of this study because they are needed for your regular medical care. You or your health plan might have to pay for other drugs or treatment given to help you control side effects. You will not also need to pay for the vaccine used in this study. Before you take part in this study, you should call your health insurer to find out if the cost of these tests, procedures, and/or the device will be paid for by the plan. Some health insurers will not pay for these costs. You will have to pay for any costs not covered by your health insurer. If you have questions while at the Clinic, please go to the Admissions and Business Services office, or you may call Patient Account Services at (507) 287-1819.

What happens if I am injured because I took part in this research study?

If you have side effects from the study vaccine treatments, you need to report them to the researcher and your regular physician, and you will be treated as needed. Mayo will bill you and your insurer for these services at the usual charge. Mayo will not offer free medical care or payment for any bad side effects from taking part in this study. You should discuss this issue thoroughly with the study doctor before you enroll in this study.

If you are hurt or get sick because of this research study, you can receive medical care at an Army hospital or clinic free of charge. You will only be treated for injuries that are directly caused by the research study. The Army will not pay for your transportation to and from the hospital or clinic. If you have questions about this medical care, talk to the principal investigator for this study, Svetomir N. Markovic, M.D., Ph.D. If you pay out-of-pocket for medical care elsewhere for injuries caused by this research study, contact the principal investigator. If the issue cannot be resolved, contact the U.S. Army Medical Research and Materiel Command (USAMRMC) Office of the Staff Judge Advocate (legal office) at (301) 619-7663/2221.

This does not mean that you are giving up any legal rights that you may have.

What are my rights if I take part in this research study?

Taking part in this research study does not take away any other rights or benefits you might have if you did not take part in the study. Taking part in this study does not give you any special privileges. You will not be penalized in any way if you decide not to take part or if you stop after you start the study. Specifically, you do not have to be in this study to receive or continue to receive medical care from Mayo Clinic. If you stop the study you would still receive medical care for your condition although you might not be able to get the study drug.

You will be told of important new findings or any changes in the study or procedures that may affect you or your willingness to continue in the study.

Who can answer my questions?

You may talk to Dr. Svetomir N. Markovic at any time about any question you have on this study. You may contact Dr. Markovic (or an associate) by calling the Mayo operator at telephone (507) 284-2511.

You can get more information about Mayo policies, the conduct of this study, or the rights of research participants from Marcia Andresen-Reid, the administrator of the Mayo Clinic Office for Human Research Protection, telephone (507) 284-2329 or toll free (866) 273-4681.

Where can I get more information about clinical trials?

You may call the NCI's Cancer Information Service at 1-800-4-CANCER (1-800-422-6237) or TTY: 1-800-332-8615

Visit the NCI's Web sites: Cancer Trials: comprehensive clinical trials information
<http://cancertrials.nci.nih.gov>

CancerNetTM: accurate cancer information including PDQ
<http://cancernet.nci.nih.gov>

Authorization To Use And Disclose Protected Health Information

Your privacy is important to us, and we want to protect it as much as possible. By signing this form, you authorize Mayo Clinic Rochester and the investigators to use and disclose any information created or collected in the course of your participation in this research protocol. This information might be in different places, including your original medical record, but we will only disclose information that is related to this research protocol for the purposes listed below.

This information will be given out for the proper monitoring of the study, checking the accuracy of study data, analyzing the study data, and other purposes necessary for the proper conduct and reporting of this study. If some of the information is reported in published medical journals or scientific discussions, it will be done in a way that does not directly identify you.

The study data sent by the study doctor to the sponsor does not include your name, address, social security number, or other information that directly identifies you. Instead, the study doctor assigns a code number to the study data and may use your initials. Some study data sent to the sponsor may contain information that could be used (perhaps in combination with other information) to identify you (e.g., date of birth). If you have questions about the specific health information that will be sent to the sponsor, you should ask the study doctor.

This information may be given to other researchers in this study (including those at other institutions), representatives of the sponsor of the study, U. S. Army Medical Research and Material Command, or private, state or federal government parties or regulatory authorities (U.S. and other countries) responsible for overseeing this research. These may include the Food and Drug Administration, the Office for Human Research Protections, or other offices within the Department of Health and Human Services, and the Mayo Clinic Office for Human Research Protections or other Mayo groups involved in protecting research subjects.

If this information is given out to anyone outside of Mayo, the information may no longer be protected by federal privacy regulations and may be given out by the person or entity that receives the information. However, Mayo will take steps to help other parties understand the need to keep this information confidential.

This authorization lasts until the end of the study.

You may stop this authorization at any time by writing to the following address:

Mayo Clinic
Office for Human Research Protection
ATTN: Notice of Revocation of Authorization
200 1st Street SW
Rochester, MN 55905

If you stop authorization, Mayo may continue to use your information already collected as part of this study, but will not collect any new information.

If you do not sign this authorization, or later stop authorization, you may not be able to receive study treatment.

What Other Things Might the Sponsor do with Study Data?

In addition to the uses listed above, companies that sponsor studies often use study data for other purposes that are not part of the study. For example, the company might use the

study data for research purposes to support the scientific objectives of the study described in this consent document, to learn more about the effects (good and bad) of any drug, device or treatment included in the study, to better understand the disease(s) included in the study, or to improve the design of future studies. Also, the company might share the study data with other companies it does business with. The company might do these things during the study, or after the study has ended, and would not have to ask for your permission to do so. The sponsor might still use study data, even after you stop your authorization, or the authorization expires, as long as the study data was collected before your authorization stopped or expired. The ways in which the study data could be used in the future may not be known now, so we can't give you the details.

A copy of this form will be placed in your medical record.

I have had an opportunity to have my questions answered. I have been given a copy of this form. I agree to take part in this research study.

(Date / Time)

(Printed Name of Participant)

(Clinic Number)

(Signature of Participant)

(Date / Time)

(Printed Name of Individual Obtaining Consent)

(Signature of Individual Obtaining Consent)