The Impact of Robotic Surgery on Surgeon Ergonomics: A Prospective Comparative Analysis to Laparoscopy to Measure Pain, Fatigue and Function

Principle Investigator: Dr. Igor Belyansky
I. **Statement of Funds**

There are no pending external funds for this project. Needed funding in excess of the $50,000 we are applying for in this grant will be from internal Department of Surgery funds.
II. **Summary**

The purpose of our study is to characterize the unique ergonomic challenges faced by novice surgeons (surgical trainees) learning to perform robotic surgery. Our goal is to identify the physical and mental stressors associated with performing surgery in an effort to reduce ergonomic risk and improve performance standards. As an academic center offering both residency and fellowship training to future surgeons, Anne Arundel Medical Center has witnessed a rapid increase in trainees asking (nearly unanimously) for robotic surgical education and training.

Though we have been enthusiastic about exposing our residents and fellows to this relatively new approach to minimally invasive surgery, we have also sought to better understand its nuances in order to optimize their learning, training and subsequent performance. We expect that these efforts will in turn positively impact patient safety in the operating room and support surgeons’ career longevity.

Accordingly, we have designed an observational and interventional simulation study intended to characterize certain ergonomic considerations of robotic surgery and compare these to the ergonomic demands of laparoscopy in an effort to reduce fatigue/strain and improve performance. Ten surgical trainees, including fellows and residents of all levels, will be recruited for this study. Participants will be given six tasks to perform on the robot and laparoscopic trainer. Each task will be performed three times each, for a total of 18 trials. Video, EMG, 3D motion capture and a variety of validated surveys will be used to collect data about posture, movement, mental/physical fatigue and performance. Once the tasks are completed, the ergonomic demands of each system will be characterized by expert ergonomists working alongside laparoscopic and robotic surgeons to develop instructions for corrective measures. Participants will perform the tasks on both the robot and laparoscopic trainer to enable assessment of ergonomic risk, pain/fatigue, performance and learning associated with both systems using a repeated measures design.
III. Background

Extreme physical and cognitive workload, poor work/life balance and pain/fatigue lead to work-related injury and burnout.\textsuperscript{1-8} Work-related pain is present in up to 87\% of surgeons\textsuperscript{8} and burnout is reported in up to 40\%.\textsuperscript{9} Both have been implicated as potential patient safety hazards.\textsuperscript{10} With the increasing complexities of operative procedures and the current climate of surgical practice, surgeons are at greater risk of work-related injury and burnout than ever before. Surgeons increasingly find themselves with a growing workload and little prospect of relief. A most important factor in the shortening of surgeon career longevity is work-related pain.\textsuperscript{1-8} Efforts to elucidate evidence-based solutions have met with limited success and produced a paltry arsenal to combat this growing pandemic among surgeons.

There is little doubt that the practice of surgery has evolved its provision of patient benefits through minimally invasive surgery (MIS).\textsuperscript{11} However, practitioner performing MIS cases on a regular basis will be subject to the cumulative, deleterious effects of unchecked ergonomic risk irrespective of age, experience, gender, height, or handedness.\textsuperscript{8} The physical stresses of performing laparoscopic MIS stem from a lack of direct visual or physical access to target anatomy, reduction in degrees of freedom, the fulcrum effect, and poorly designed tools, resulting in awkward, sustained working postures, highly repetitive motion, and a limited 2-dimensional view of the operative field.\textsuperscript{8}

Robotic surgery has gained tremendous global momentum since its introduction in 2000\textsuperscript{11}. Nearly 450,000 cases were performed using robotic systems in 2012, a number 29\% higher than the previous year. The surge in the use of robotic systems has been propelled by two important factors; the continued growth in global demand for MIS and cutting-edge technological contributions of the robot to MIS, allowing 3-dimensional perception, enhanced degrees of freedom, motion scaling and tremor reduction.

Although some initial studies have supported the potential ergonomic benefits and expedited task performance of robotic systems over laparoscopy\textsuperscript{11-17}, the true impact of this new technology remains to be fully defined. In general, robotic surgery demands longer operative times and may
present ergonomic hazards that target alternative anatomic regions (e.g., cervical spine as opposed to lower back) which will manifest more broadly among practitioners with continued use.

As expected, skilled practitioners who can employ sound ergonomic postures and positions during robotic surgery (with lower shoulder position and reduced application of pressure to the arm rests) may benefit from its advantages while avoiding strain and injury\textsuperscript{11}.

Nevertheless, the unique ergonomic challenges of robotic surgery have yet to be completely defined. This may have significant negative consequences for less experienced surgeons and those in training who are progressively exposed to more robotic surgery. Studies to elucidate these ergonomic challenges may not only provide appropriate guidelines and education for surgeons interested in robotic surgery, but may also serve to enhance their learning and performance while reducing their strain and fatigue.

IV. Hypotheses

The purpose of our study is to characterize and compare the unique ergonomic challenges associated with robotic surgery to those of laparoscopic surgery for novice surgeons (residents and fellows in surgical training) in a simulated setting. Furthermore, we will explore the potential to mitigate these ergonomic challenges to reduce physical and mental fatigue and strain while enhancing learning and performance for surgeons in training. Our hypotheses are:

1) Performing a battery of advanced MIS tasks robotically will result in greater strain in the neck, shoulders and arms than performing the same task battery laparoscopically.

2) The overall level of pain, fatigue, and discomfort associated with laparoscopic task performance will exceed that of performing the same tasks robotically.

3) Mitigating ergonomic risk associated with robotic surgery will be more practical than mitigating that of laparoscopic surgery.
4) These may lead to improved ergonomic guidelines for robotic surgery, effectively reducing mental and physical stress, facilitating learning of surgical techniques, reducing errors, and enhancing performance of novice surgeons.

V. Methods

Section 1, Hypothesis 1

Robotic surgery is associated with unique ergonomic risk areas in comparison to laparoscopic surgery for novice surgeons (residents and fellows), with a greater level of strain on the neck, shoulders and arms than the latter approach.

Study Design

1. After institutional review board (IRB) approval, this study will be performed in the simulated operating rooms of the Research/SAIL Center at Anne Arundel Medical Center.

2. 10 novice surgeons (fellows and residents) will be recruited for this study.

3. Six proprietary tasks designed by Dr. Park and Ivan George for training on the laparoscopic trainer box with projected broad transference to common minimally invasive surgical cases (hernia repair, Nissen fundoplication, sleeve gastrectomy and colectomy) will be used to test participants. These tasks comprise what we term Advanced Laparoscopic Simulation Tasks (ALST).

4. These tasks will test precise motor control, instrument rotations and opening and closing of the end effector. Specifically, the tasks include: 1) Closing an open zip tie without touching the walls or the trainer box, 2) Inverted circle cutting, 3) Inverted PEG transfer, 4) 90 degree intracorporeal suturing, 5) Passing the Keith needle through the spinal needle and 6) Dissection of rubber band out of gelatinous encasing.

5. All tasks will be performed by all participants, via counterbalanced measures approach, on the robot and traditional laparoscopic trainer box.
6. Each surgeon will perform all tasks a total of six times: three utilizing the robot and three utilizing the laparoscopic trainer box. The order of performance of task will be randomly assigned.

7. Video will be recorded from two views, one directed at the monitor to capture procedural details and the other will be directed at the surgeon and assistants movements and interactions.

8. The physical ergonomics relative to each procedural trial will be evaluated by two independent observers using the Rapid Upper Limb Assessment (RULA) tool (a widely used physical ergonomics tool as relates to upper limb disorder from exposure to work related risk factors). Inter-rater reliability will be assessed.

9. During the performance of tasks, motion analysis data using a ViconPeak motion capture system will be collected. Data from markers placed on each surgeon subject will be reviewed to assess form, motion and posture.

10. During the performance of tasks, surface electromyography (EMG) to assess muscular workload, and ground effects force plates to assess postural stability/instability will be reviewed. EMG will target the following forearm and hand muscles according to prior studies\(^1,2\): thenar muscle, extensor digitorum communis (EDC), flexor digitorum superficialis (FDS), flexor carpi radialis (FCR), and flexor carpi ulnaris (FCU).

11. The AVCA tool, a comprehensive measure of surgeon visual comfort during minimally invasive surgery, utilizing combined parameters from the validated Maryland Visual Comfort Scale (MVCS)\(^4\) and the validated discernibility threshold (DT)\(^5\) tool will be used and tested to determine its validity in evaluating surgeon visual comfort. (Refer to Form A, Appendix 1)

12. Each surgeon will have their visual comfort and perception of image quality analyzed at the start and after completion of all tasks on the robot vs. laparoscopic trainer box.

13. Performance scores will also be calculated for each task and will be compared between the robotic vs. laparoscopic approaches, comparing each surgeon to self as well as overall
performance between the 2 groups. Scoring will be performed according to the MISTELS program (Derossis et al, 1999). Briefly, for each exercise, a timing component will be calculated by subtracting the time to complete the exercise from a preset cutoff time (timing component= cutoff time [seconds] – time to complete the exercise [seconds]). The scoring will reward faster performance. Times will be determined pre-study by pilot trials of tasks by both novice and expert surgeons on simulators. If time to complete the exercise surpasses the preset cutoff time, a score of zero will be assigned. Precision will be scored by calculating a penalty component for each exercise. The score for each exercise will be calculated by subtracting the penalty from the timing component, rewarding accuracy and speed. A total score will be derived for each participant by adding their scores from all six exercises.

14. Mental workload assessments will be conducted using the National Aeronautics and Space Administration Task Load Index (NASA-TLX) subjective tool after each trial/performance.

15. Finally, at the completion of each set of tasks, the overall physical ergonomics relative to each surgery will be evaluated using Form B in Appendix 1. This is a full body assessment of pain and fatigue experienced by the surgeon applicable to simulation or live surgery. (Refer to Appendix 1)

Section 2, Hypotheses 2-4

2) The overall level of pain, fatigue, and discomfort associated with laparoscopic task performance will exceed that of performing the same tasks robotically.

3) Mitigating ergonomic risk associated with robotic surgery will be more practical than mitigating that of laparoscopic surgery.

4) These may lead to improved ergonomic guidelines for robotic surgery, effectively reducing mental and physical stress, facilitating learning of surgical techniques, reducing errors, and enhancing performance of novice surgeons.
We will compare the video, EMG, motion analysis, visual comfort, RULA, NASA-TLX and ergonomic survey data collected during our simulated trials to characterize differences between robotic and laparoscopic ergonomics.

Expert ergonomists, as well as, laparoscopic and robotic surgeons (greater than 4 years of Attending experience) will review the ergonomics of participants and provide instructions on corrective measures. Participants will subsequently repeat all experiments under section 1 to determine the validity of hypotheses 2-4.

Statistical Analysis

Data will be analyzed using two-way repeated-measures ANOVA. This will allow for acquiring p values for various effects of using the robot versus the laparoscopic trainer box and their respective effects. Further ANOVA analysis of variance with repeated measures design will be applied to all data to investigate the physical workload and cumulative muscular workload associated with the various instrument trials (configurations). The main effects of measured factors and their interactions will be reviewed.
VI. Budget

Detailed budget for 12 month period from January 2017 through December 2017.

Dollar amount requested (Omit cents) **$50,000**
Total for the grant request may not exceed $50,000.

* Salary funds should be used for staff required to execute the study, but should not be used for salary support for the primary investigator. If salary support exceeds 50% of the project budget, then specific justification is required.

** Funds requests for travel for the presentation of a SAGES funded study should be limited to $1,000.

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<td>Principal Investigator*</td>
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<td>2. T. Robert Turner</td>
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<td>3. H. Reza Zahiri</td>
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<td>4. Adrian Park</td>
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<td>5. Research Assistant</td>
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| EQUIPMENT (List all Items & Total Equipment Cost) | ROBOT training reposable arms ($300/unit=$1500 total); EMG usage fee ($5000); 2 reference electrodes ($7/unit=$14 total); 1 input module reference cable ($20 total); Motion Capture Lab usage fee ($5000); warranty and servicing ($3000); software ($1500); minor capital equipment ($5000); Force Plate usage fee ($2000) | $23,034     |
| SUPPLIES (List all Items & Total Supplies Cost) | ROBOT zip ties ($20 total); circle cutting ($50 total); PEG transfer ($50 total); Keith needle ($20 total); blunt fine dissection model ($5.80/unit=$350 total); EMG 480 adhesive tapes ($30/60 units=$240 total); Motion Capture supplies ($2000) | $2,730      |
| TRAVEL** | P.I. travel expenses to travel to present at SAGES | $1,000      |
| PATIENT CARE COSTS | n/a | $ -         |
| CONSORTIUM/CONTRACTUAL COSTS | n/a | $ -         |
| OTHER EXPENSES (List all Items & Total Cost) | Statistician ($600); Manuscript development/Editor ($500); | $1,100      |

**TOTAL DIRECT COSTS** | **$50,000** |
VII.  **Budget Justification**

**PERSONNEL**

Igor Belyansky, M.D., Principal Investigator  
Dr. Belyansky will be responsible for the overall coordination and supervision of all aspects of the study. This includes supervising staff/students; recruiting study participants; coordinating assessment components; and data management. In addition, he will be responsible for reporting the study’s findings.

T. Robert Turner, Ph.D., Co-Investigator  
Dr. Turner will be responsible for administration, collection and analyses of the data.

Adrian Park, M.D., Co-Investigator  
Dr. Park will be responsible for the coordination and supervision of the study. He will also assist in manuscript preparation.

H. Reza Zahiri, M.D., Co-Investigator  
Dr. Zahiri will be responsible for recruiting study participants; coordinating assessment components; analyses of the data. He will also assist in manuscript preparation.

**OTHER PERSONNEL**

TBA Research Assistant.  
(effort = 12 Calendar Months). This individual will coordinate the day-to-day management of the study, assist in assessments, be responsible for data entry of all study-related data.

**CONSULTANT**

Funds ($5000) are requested for the use and reservation of dedicated space in the simulation laboratory to conduct this study.

**EQUIPMENT & SUPPLIES**

Funds are requested for the use of the different technological equipment needed to support this study. These have been categorized as Robot, EMG, Motion Capture Lab, or Force Plate related. Additional funds are requested to purchase disposable supplies associated with each equipment.

**TRAVEL**  
- $1000 in Year 01 is requested for travel to SAGES to present findings associated with the investigation.

**MANUSCRIPT**  
- $600 in Year 01 is requested for statistical support and an additional $500 is requested for editorial assistance with manuscript development.
VIII. References


IX. Local/Institutional Review Board
A member of the institutional Clinical Research Review Committee (CRC) has reviewed this application and protocol proposal. Approval in principle has been granted.

X. Available Resources

Facility:
Anne Arundel Medical Center
Surgical Ergonomics/Motion Laboratory
James and Sylvia Earl Simulation to Advance Innovation in Learning (SAIL) Center
2000 Medical Parkway
Belcher Pavilion, Suite 104
Annapolis, MD 21401

The James and Sylvia Earl Simulation to Advance Innovation and Learning (SAIL) Center is a 5500 ft² world-class medical simulation and training facility in Annapolis, Md., located a few
miles from the Chesapeake Bay. The Center is part of Anne Arundel Medical Center, a 380 bed not-for-profit, independent hospital.

The mission of the SAIL Center is to promote the provision of safe care for patients through advanced training that is ahead of the rest of the country and usually available only in major academic medical centers. Additionally, as part of its mission and infrastructure, the SAIL Center is designed to foster the creation, co-development and evaluation of intellectual property in a more cost effective, efficient and incentivized fashion than academic medical centers. The SAIL Center provides an environment dedicated to conducting world-class clinical research, training the next generations of healthcare providers, and facilitating efforts that will ensure excellence in the medical practices of the future.

The Center hosts teleconferences, monthly national multi-center teleconferences, lectures, research, and large group sessions for resident surgical education, all of which help to develop staff skills and knowledge. The SAIL Center serves not only the medical profession, but it also provides tours and educational opportunities for area school children, the community, patients, families and organizations dedicated to healthcare improvement and patient safety.

The SAIL Center is also engaged in various research studies and initiatives designed to improve the delivery of health care and the practice of medicine. A major part of its mission revolves around continuing medical education of healthcare practitioners and improving patient care and safety. A major component of the SAIL Center is the Surgical Ergonomics/Motion Laboratory, a full-scale simulated operating room suite (400 ft², pictured) outfitted as a functional research laboratory with the following specialized equipment (current and available year-round):

- Vicon MX 40 3D Motion Capture and Reconstruction System (10 ceiling-mounted cameras) for measures such as joint angles and velocity or surgical economy of movement.

- 2 AMTI OR6-1000 Series Force Plates for recording ground reaction forces, supporting analysis of postural control and stability, sway, and gait.
• Delsys Bagnoli 16-channel surface EMG for recording and analyzing mean muscular activity, or the degree to which specified muscles or muscle groups are recruited to carry out motor tasks.

• ISCAN Eye and Target Tracking System for studying visual attention and fatigue with a range of available metrics such as fixation frequency and duration, pupil dilation, blink rate and so on.

Figure 1. AAMC’s Surgical Ergonomics/Motion Laboratory located within the SAIL Center
BIOGRAPHICAL SKETCH

Provide the following information for the senior/key personnel and other significant contributors. Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

**NAME:** Igor Belyansky

**eRA COMMONS USER NAME** (credential, e.g., agency login): IBELYANSKY

**POSITION TITLE:** Director, Abdominal Wall Reconstruction Program

**EDUCATION/TRAINING** (Begin with baccalaureate or other initial professional education, such as nursing. Include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<tr>
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<td>Union Memorial Hospital, Baltimore, Maryland</td>
<td>Residency</td>
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<td>Virginia Commonwealth University School of Medicine, Richmond, Virginia</td>
<td>MD</td>
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<td>University of Maryland, College Park, Maryland</td>
<td>BS</td>
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**A. Personal Statement**

Having trained and now practicing at a University Teaching Hospital, I have more than 10 years of experience as an investigator, with more than 40 publications, abstracts, and scientific podium presentations. My practice is focused on abdominal wall reconstruction. I am delighted and honored to be included in the submission of this important grant.

**B. Positions and Honors**

**Positions**

- **January 2013 to present** Director of Abdominal Wall Reconstruction Program at Anne Arundel Medical Center, Annapolis, Maryland
- **January 2015 to present** Director of Surgical Education at James and Sylvia Earl SAIL (Simulation to Advance Innovation and Learning) Center, Annapolis, Maryland
Honors

1. Outstanding Research Resident Award, Union Memorial, Baltimore, MD, June 2010


3. Gold Medal Presentation at American Hernia Society, San Francisco, California, March 2011. "The Carolinas Comfort Score is a Reliable and Sensitive Measure of Patient Quality of Life After Mesh Hernia Repair with up to 4 Years of Follow-up."


C. Contribution to Science (Publications/Abstracts/Presentations/etc.)


Flap Development or Panniculectomy is Safe and does not Lead to Increased Post-operative Pain. Submitted to Journal of Surgical Innovation, 2012.


D. Research Support (Current, Pending, and Completed; include any support received from FPT).


4. NG-TSM mesh evaluation in a chronic pig model. Ethicon, Inc. 2010. $401,136.56.


BIOGRAPHICAL SKETCH

Provide the following information for the senior/key personnel and other significant contributors. Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Hamid Reza Zahiri

eRA COMMONS USER NAME (credential, e.g., agency login): HZAHIRI2

POSITION TITLE: Minimally Invasive Surgeon

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<tr>
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<td>Midwestern University</td>
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<td>Phoenix, Arizona</td>
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A. Personal Statement

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B. Positions and Honors

**POSITIONS**

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<tr>
<td>2016-Present</td>
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<td>2015-2016</td>
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2014-2015 Research Fellowship, Minimally Invasive Surgery, Anne Arundel Medical Center, Annapolis, MD

2013-2014 Chief Resident, General Surgery, University of Maryland, Baltimore, MD

2011-2013 Senior Resident, General Surgery, University of Maryland, Baltimore, MD

HONORS

April 16, 2013 Outstanding Laparoendoscopic Resident Surgeon Award, Society of Laparoendoscopic Surgeons

May 18, 2012 Best Paper Presented, 55th Annual Ohio Valley Society of Plastic Surgeons Meeting, "Use of Porcine Acellular Dermal Matrix As Resurfacing Graft To Promote Epithelialization of Avascular Wounds"

February 8, 2012 Resident Research Award, Baltimore Academy of Surgery, "Use of Porcine Acellular Dermal Matrix As Resurfacing Graft To Promote Epithelialization of Avascular Wounds"


August 16, 2009 $78,405 Unrestricted Education Grant from LifeCell Corporation for study "Use of Porcine Acellular Dermal Matrix As Resurfacing Graft To Promote Epithelialization of Avascular Wounds"

March 2, 2005 Selected to Sigma Sigma Phi Honor Society for academic excellence

October 23, 2004 Certificate of research recognition, American College of Physicians

October 12, 2003 Best medical student poster presentation, 108th Annual AOA National Convention and Scientific Seminar

June 2, 2003 Outstanding Research Award, Midwestern University

C. Contribution to Science (Publications/Abstracts/Presentations/etc.)


D. Research Support (Current, Pending, and Completed; include any support received from FPT).

May 15, 2004
Private Grant, Midwestern University
Amount: $4000.00
Project Title: “Chromatin Unwinding by the UvrD DNA Repair Helicase”
Role: Co-investigator
BIOGRAPHICAL SKETCH

Provide the following information for the senior/key personnel and other significant contributors. Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Timothy Robert Turner Jr.

eRA COMMONS USER NAME (credential, e.g., agency login): TURNERTR16

POSITION TITLE: Director, Surgical Research

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>08/2006</td>
<td>Industrial/Organizational Psychology</td>
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<td>Old Dominion University (Norfolk, VA)</td>
<td>PHD</td>
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A. Personal Statement

Dr. Robert Turner is the Director of Surgical Research at Anne Arundel Medical Center in Annapolis, MD. He has 10 years of experience conducting research in healthcare human factors/ergonomics, with an emphasis in general surgery, in both military and civilian settings. His current efforts involve characterizing the unique biomechanical and cognitive challenges associated with minimally invasive surgery in an effort to mitigate surgeon burnout and cumulative musculoskeletal complications. Additional research interests include user-centered design considerations for biomechatronic devices and the impact of neural interfaces and high-stakes environments on cognitive function.

B. Positions and Honors

Recent Positions:

Anne Arundel Medical Center (Annapolis, MD)
Director, Department of Surgical Research
2016 - Present

American College of Surgeons (Chicago, IL)
Assistant Director, Simulation-Based Surgical Education and Training
Division of Education
2013 - 2016
Virginia Modeling, Analysis and Simulation Center (Suffolk, VA)
Senior Project Scientist
Medical and Healthcare Research Division
2012 - 2013

Naval Medical Center Portsmouth (Portsmouth, VA)
Research Psychologist, Human Factors
Team Resource Training Center
2009 - 2011

Honors and Awards:
Second Place Paper, 12th Annual International Meeting on Simulation in Healthcare, 2012
Best Individual Action Plan - HFES National Ergonomics Month - First Place, 2011
Best Paper, Health & Medicine Track, MODSIM World Conference & Expo, 2010
Student Member with Honors Award, Human Factors & Ergonomics Society, 2009
Gold-level Award, Human Factors & Ergonomics Society Student Chapter (President), 2009
Best National Ergonomics Month Action Plan, HFES Chapter (President) - Third Place, 2009
Second Place Paper, Medical Track; Virginia Modeling, Analysis, and Simulation Center Capstone Conference, 2009
Second Place Paper, 9th Annual International Meeting on Simulation in Healthcare, 2009
Best Paper, 49th Annual Meeting of the Southeastern Psychological Association, 2003
Best Undergraduate Poster, 53rd Annual Mississippi Psychological Association Conference, 2002

C. Contribution to Science (Publications/Abstracts/Presentations/etc.)


education: Establishing an educational framework for proficiency in surgical education”; Tampa, FL.


D. Research Support (Current, Pending, and Completed; include any support received from FPT).
   March 11, 2016
   Stryker Endoscopy
   Amount: $782,702.88
   Project Title: “Caring for the Caregiver of the Future”
   Role: Co-investigator
A. Personal Statement

I have more than 20 years of experience as a surgeon, investigator and innovator. Having spent the majority of my career in University Teaching Centers, my clinical focus has been on tertiary G.I. Surgical care and the development of new techniques and technologies to advance the field. I have been a surgical educator as well as a researcher. As the PI on several large Dept. of Defense grants I supervised a team whose work gave rise to the generation of intellectual property in addition to scholarly publications. I have 10 U.S. patents and multiple international ones. I am delighted and honored to be included in the submission of this important grant.

B. Positions and Honors

1994 - 1997  Courtesy Staff, Chedoke McMaster Hospitals, Canada
1994 - 1997  Consultant, Division of General Surgery, St. Peter’s Hospital, Canada
1994 - 1997  Active Staff, Department of Surgery, St. Joseph’s Hospital, Canada
1994 - 1997  Asst. Clinical Professor, Dept. of Surgery, Faculty of Health Sciences, McMaster University, Canada
1999 - 2003  Chief, Section of G.I. Surgery, University of Kentucky College of Medicine, Lexington, KY
1998 - 2003  Head, Surgical Endoscopy, University of Kentucky, Lexington, KY
1998 - 2003  Director, Center for Minimally Invasive Surgery, University of Kentucky, Lexington, KY
1997 - 2003  Associate Professor, Dept. of Surgery, University of Kentucky College of Medicine, Lexington, KY
2003 - 2003  Professor, Department of Surgery, University of Kentucky College of Medicine, Lexington, KY

2003 - 2011  Professor of Surgery & Head, Division of General Surgery, University of Maryland, Baltimore, MD

2005 - 2011  Medical Director, Digestive Health Center, University of Maryland, Baltimore, Maryland

2005 - 2011  Adjunct Professor, Bioengineering, University of Maryland, Baltimore, Maryland

2006 - 2011  Vice Chair, Department of Surgery, University of Maryland, Baltimore, Maryland

2011 - 2011  Chief of Surgery, Capital District Health Authority, Halifax, Nova Scotia

2011 - 2011  Professor of Surgery & Chairman, Department of Surgery, Dalhousie University, Halifax, Nova Scotia

2011 – Present  Adjunct Professor of Computer Science & EE, University of Maryland (BC)

2012 – Present  Chairman, Department of Surgery, Anne Arundel Health System, Annapolis, Maryland List any honors. Include present membership on any Federal Government public advisory committee.

2013 – Present  Professor of Surgery, PAR, Johns Hopkins University School of Medicine

**Selected Honors and Awards**

1999  Alumni Medal of Achievement, University of Guelph


2009  Medal of Achievement. University of Maryland School of Medicine

2009  Gore & Associates Outstanding Achievement Award – A SAGES Foundation Award


6/13  Georgetown University Lifetime Achievement Award in Abdominal Wall Reconstruction.

**Inventions, Patents, Copyrights**

1.  An Anastomotic Device for Minimally Invasive Surgery. (Serial # 10/175,159 Patent Pending)

3. Multiple Frame Integration and Histogram Modification to Improve Contrast during Minimally Invasive Surgery. (Invention Disclosure #960)


5. Structure Laser Light System to Achieve Three Dimension Projection of a Two Dimensional Image in Real Time During Laparoscopic Surgery. (Invention Disclosure #1067)

6. Barrell Distortion Correction to Improve Perspective and Geometry in Laparoscopic Imaging Systems. (Invention Disclosure #1068)

7. The Park (Laparoscopic) Forceps.

8. The University of Kentucky Surgical Trainer Box.

9. The University of Kentucky/Stryker Surgical Training Module.

10. Adjustable Line Retractor. (APPL NO. 60/850,496)

11. Adjustable Net Retractor. (APPL NO. 60/850,708)

12. Endo Frame. (Application No.: 60/922,515 Docket No.:16640.0003)


19. An Endoscopic surgical device for measuring hernia defects and other anatomic geometries for clinical planning. (Invention Disclosure # Pending)


30. Handle for a surgical instrument. Pending (submitted March 27, 2012)


C. Selected Peer-reviewed Publications


**D. Research Support**

**Ongoing Support**

Research Study – Addressing MSDs amount Laparoscopic Surgeons 2010-2013
NIOSH
PI: **Park A**.

**Completed Support**

Research Study – Ergonomics of a Wireless Camera 2010-2011
Stryker
PI: **Park A**.

Research – Strategies for Application of Surgical Innovations (Conference Support) 2010
USA Med Research ACQ Activity
PI: Moses G
Role: Co-PI: **Park A**.

Research – Comparative Assessment of Physical and Cognitive workloads associates with Robotics and Traditional Laparoscopic Surgeries. 2011
Intuitive Surgery Operations, Inc.
PI: Lee G
Role: Co-PI: **Park A**
### XI. Participation in SAGES

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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</thead>
<tbody>
<tr>
<td>Igor Belyansky</td>
<td>Present Hernia Task Force</td>
</tr>
<tr>
<td>Adrian Park</td>
<td>2011 – Present Chairman, SAGES Hernia Task Force</td>
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<tr>
<td></td>
<td>2013 – 2015 Vice President SAGES</td>
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<tr>
<td>H. Reza Zahiri</td>
<td>Multiple abstract presentations at SAGES</td>
</tr>
</tbody>
</table>
XII. Appendix 1

Form A

Directions: Please complete the following survey just before and right after completion of all tasks on the robot vs. laparoscopic trainer box. Your responses to this section should be provided while looking at target anatomy at the central region of the screen as illustrated below.

1. On a 1-10 scale how would you rate the contrast of the target anatomy as displayed on the screen?

   1  2  3  4  5  6  7  8  9  10
   Unable to Distinguish Target  Easy to Distinguish Target

2. On a 1-10 scale how would you rate the detail (resolution) of the target anatomy as displayed on the screen?

   1  2  3  4  5  6  7  8  9  10
   Unable to Distinguish Target  Easy to Distinguish Target
3. On a 1-10 scale how would you rate the brightness of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10

Unable to | Easy to
Distinguish Target | Distinguish Target

4. On a 1-10 scale how would you rate the lighting uniformity (the perceived reduction of illumination in the visible periphery of the displayed image) of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10

Unable to | Easy to
Distinguish Target | Distinguish Target

5. On a 1-10 scale how would you rate the focus uniformity (the peripheral distortion of lack of sharp focus at the visible periphery of the displayed image) of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10

Unable to | Easy to
Distinguish Target | Distinguish Target

6. On a 1-10 scale how would you rate the color of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10

Unable to | Easy to
Distinguish Target | Distinguish Target
7. On a 1-10 scale how would you rate the sharpness of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10
Unable to Distinguish Target

8. On a 1-10 scale how would you rate the overall image quality of the target anatomy as displayed on the screen?

1  2  3  4  5  6  7  8  9  10
Unable to Distinguish Target

---

**Form B**

This section is to be completed **before** each task.

1. How would you rate your level of discomfort PRIOR to the start of this task today? (Circle the number from 0 = no discomfort, 10 = worst possible)

   **Neck**

   0  1  2  3  4  5  6  7  8  9  10

   **Right Shoulder**
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</table>
2. How would you rate your level of fatigue prior to the start of this task today?
   (Circle 0 = no fatigue, 10 = extremely fatigued)
   
   0  1  2  3  4  5  6  7  8  9  10

A. This section will be completed by a research team member.

   Surgical Procedure: __________________________________________________________

   Laparoscopic Approach or Robotic Approach:

   time task started: _____________  time task ended: ________________

   Total time of procedure: ________________________ (hh:mm)

   Position:  □ standing       □ sitting       □ combination

This section is to be completed after each task.

1. How would you rate your level of discomfort? (0 = no discomfort; 10 = worst possible)

   Neck

   During  0  1  2  3  4  5  6  7  8  9  10
   After   0  1  2  3  4  5  6  7  8  9  10

   Right Shoulder

   During  0  1  2  3  4  5  6  7  8  9  10
   After   0  1  2  3  4  5  6  7  8  9  10

   Left Shoulder

   During  0  1  2  3  4  5  6  7  8  9  10
After 0 1 2 3 4 5 6 7 8 9 10

Right Wrist/hand

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Left Wrist/hand

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Lower Back

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Upper Back

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Right Knee

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Left Knee

During 0 1 2 3 4 5 6 7 8 9 10
After 0 1 2 3 4 5 6 7 8 9 10

Right Ankle/Foot
### Left Ankle/Foot

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</table>

1. How mentally demanding was the task?

   0 1 2 3 4 5 6 7 8 9 10
   Very Low       Very High

2. How physically demanding was the task?

   0 1 2 3 4 5 6 7 8 9 10
   Very Low       Very High

3. How complex was the task?

   0 1 2 3 4 5 6 7 8 9 10
   Very Low       Very High

4. How distracting was the surrounding environment?

   0 1 2 3 4 5 6 7 8 9 10
   Very Low       Very High
5. What was the degree of difficulty for this task?

0 1 2 3 4 5 6 7 8 9 10
Extremely easy, Extremely difficult;
planes well-defined; invisible planes;
no scar tissue or edema excessive scarring

6. Circle your level of fatigue. (0 = no fatigue, 10 = extremely fatigued)

During 0 1 2 3 4 5 6 7 8 9 10

After 0 1 2 3 4 5 6 7 8 9 10