



# Evaluation of Various Sensing Modalities for Accurate Measurement of Neck Flexion Angle during Thyroid and Ear Surgery

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# Background

- Ear Surgery
  - Traditional case: looking through microscopes
  - Endoscopic case: looking at monitor
- Thyroid Surgery
  - Traditional case: standing over patient
  - Endoscopic case: looking straight at a monitor



Pictures from:  
<https://oklahoman.com/gallery/articleid/3808606/>



<http://amandeepmedicity.org/specialities/bariatric-metabolic-surgery>



<http://www.tristonekidneyhospital.com/index.html>

# Significance

- Poor surgical ergonomics may lead surgeon disability
  - 2/3 of respondents reported neck discomfort related to their occupation–94% of surgical residents have musculoskeletal pain [1]
  - Prevalence of musculoskeletal symptoms in the neck and shoulders is as high as 87% [2]
  - Back pain most common

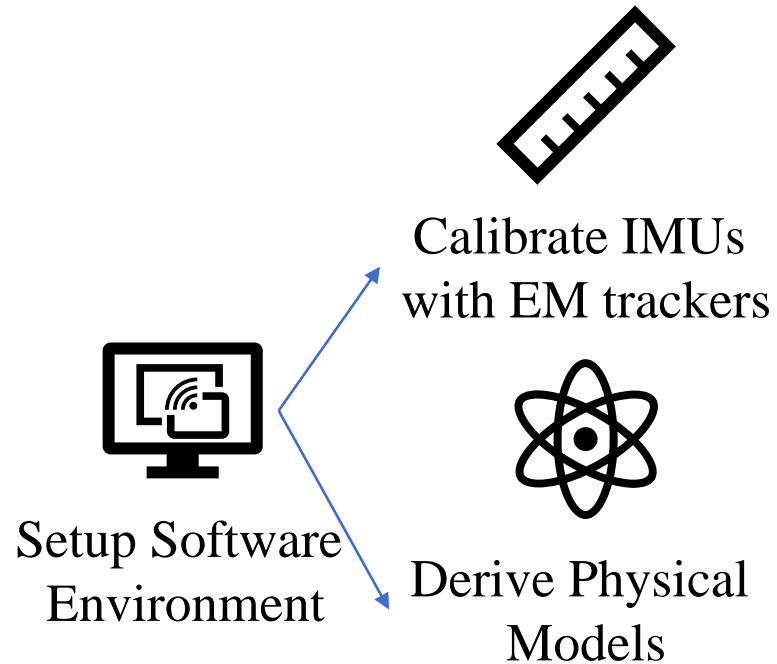
1.Khansa I, Khansa L, Westvik TS, Ahmad J, Lista F, Janis JE. Work-related musculoskeletal injuries in plastic surgeons in the United States, Canada, and Norway. *Plast Reconstr Surg.* 2018;141(1):165e-175e.

2.Capone AC, Parikh PM, Gatti ME, Davidson BJ, Davison SP. Occupational injury in plastic surgeons. *Plast Reconstr Surg.* 2010;125(5):1555-1561.

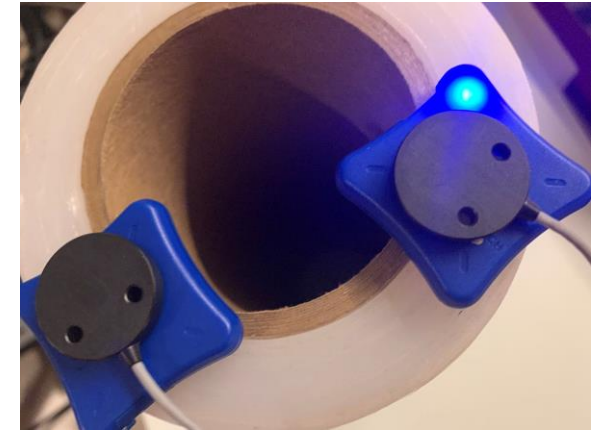
# Goals

Evaluation of Various Sensing Modalities for Accurate Measurement of Neck Flexion Angle during Thyroid and Ear Surgery using IMUs.

# Technical Approach

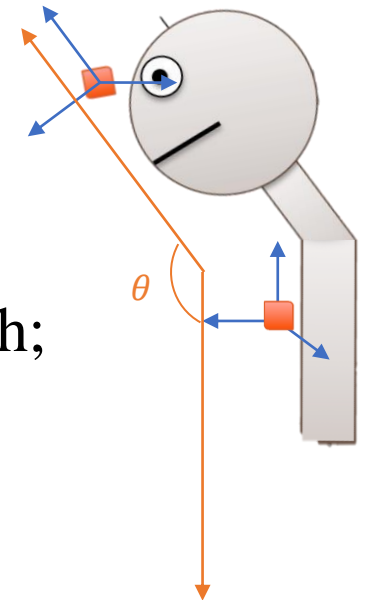


IMU: Inertial measurement unit  
3-axis gyroscope  
3-axis accelerometer  
3-axis magnetometer



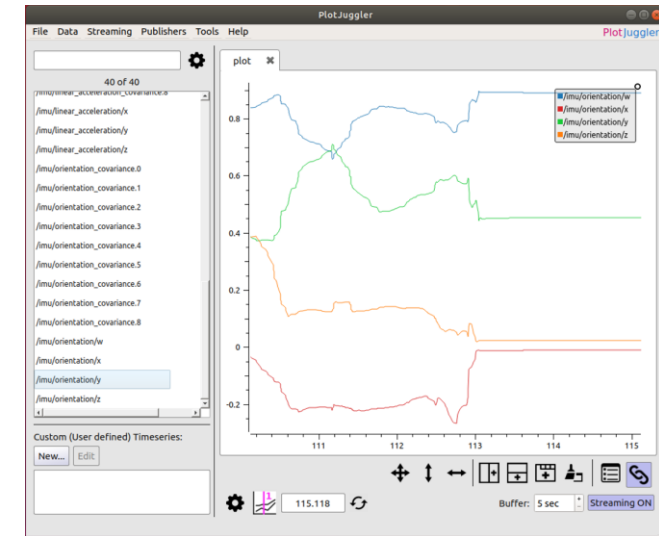
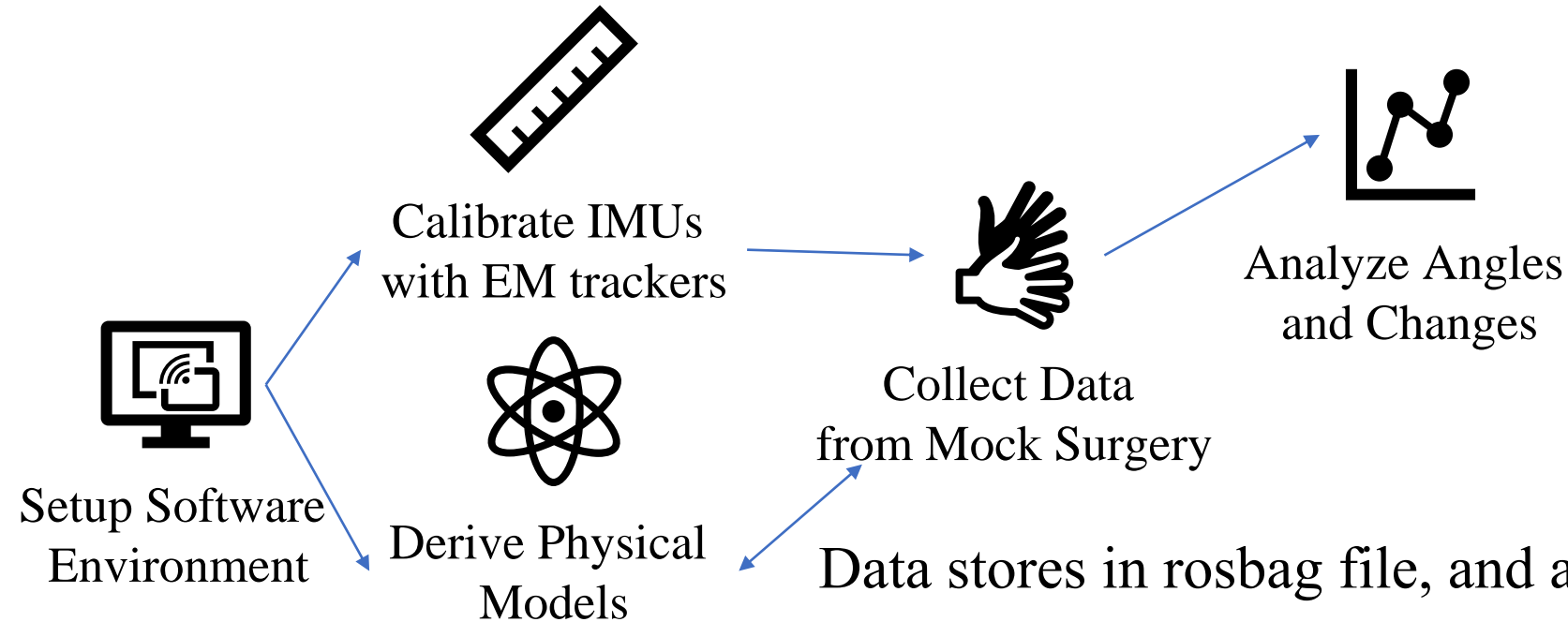
EM tracker: Electromagnetic tracker  
-- External ground truth system

1. Calibrate every IMU by the ground truth;
2. Derive pitch angle from 6 sensors data;
3. Validate the pitch angle.



System: Linux & ROS  
Package: lpms-imu;  
ndi\_tracker\_ros

# Technical Approach



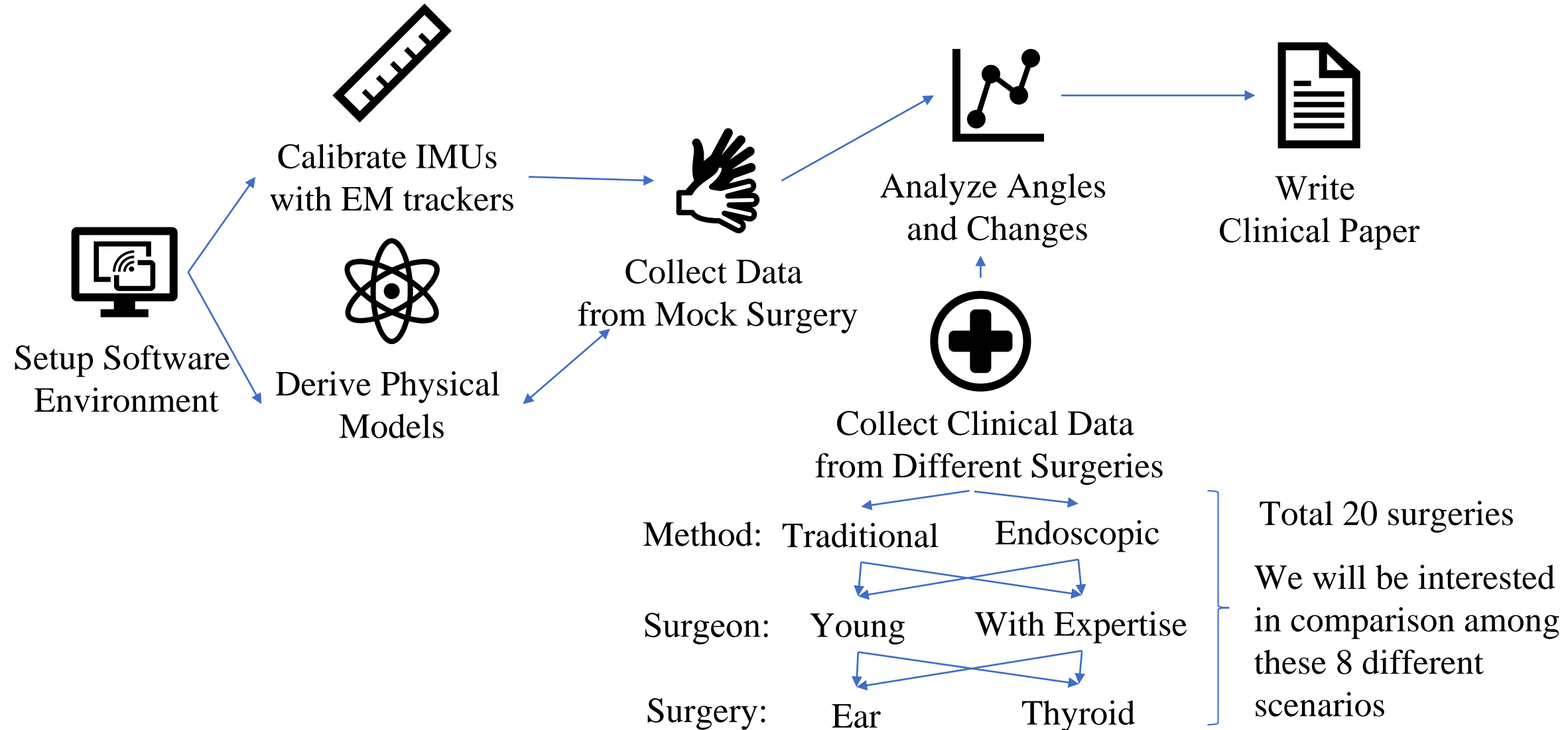
Data stores in rosbag file, and analyze using MATLAB

1. Signal processing, like Kalman filter, if needed
2. Calculate neck flexion angle from mathematical model

We will be interested in such data:

1. The largest angle
2. The angle last for a long time

# Technical Approach



# Deliverables

- Minimum: (Expected before Mar.6)
  - Calibration result of two IMUs separately against EM tracker (excel file)
  - Validation result of the pitch angle (excel file)
  - Documentation of software setting and calibration steps (doc file)
- Expected: (Expected before Mar.12)
  - Data analysis report of phantom study
- Maximum: (Expected before May.5)
  - Data analysis report of real surgical scenarios
  - Clinical paper

# Time schedule

	Feb,15 - Feb,21	Feb,22- Feb, 28	Feb,29- Mar, 6	Mar,7- Mar,11	Mar,12- Mar,20	Mar,21- Mar,27	Mar,28- Apr,3	Apr,4 - Apr,10	Apr,11- Apr,17	Apr,18- Apr,24	Apr,25- May,1	May,1- May,5
Set up the computer and document installation steps (Zhen and Hanqing)	☑	☑	☑									
Calibration and document steps (Hanqing)												
Derive mathematical model of neck angle and document steps (Zhen)		☑	☑									
First measurement in Mock OR & First data analysis (Zhen and Hanqing)				☑								
Human Subjects Research Training and IRB approval	☑	☑	☑	☑								
20 measurement in real surgery scenarios & Each one do data analysis (Zhen and Hanqing)					☑	☑	☑	☑	☑			
Overall analysis and documentation of the difference between various scenarios (Zhen and Hanqing)								☑	☑	☑		
Write clinical paper (Zhen and Hanqing)		☑								☑	☑	☑

☑ : Finished stuff    ☑ : Planned stuff

# Milestones

Date	Detailed Description
February, 21	Linux and ROS environment configuration finished
February, 26	Project proposal finished
February, 26	Human Subjects Research Training finished
March, 6	Calibration of IMUs and mathematic model derivation finished
March, 6	Documentation of environment configuration and calibration method finished
March, 11	IRB approval
March, 11	First measure in Mock OR and analysis of the data finished
April, 17	20 measurements in real surgery and analysis of the data finished
April, 24	Analysis of the difference between various surgery scenarios finished
April, 24	Documentation of data collection and data analysis finished
May, 4	Clinical paper finished

# Dependencies

Dependencies	How to resolve	Alternative Plan	Date Expected	Date Needed
IRB approval	<ol style="list-style-type: none"> <li>1. Finish Human Subjects Research Training on Mylearning</li> <li>2. Get IRB approval with the help of Dr. Deepa Galaiya</li> </ol>	Do all the measurement in Mock OR	<ol style="list-style-type: none"> <li>1. Feb,24</li> <li>2. Mar,6</li> </ol>	<ol style="list-style-type: none"> <li>1. Feb,26(Solved)</li> <li>2. Mar,11(In progress)</li> </ol>
Computer with Linux & ROS	<ol style="list-style-type: none"> <li>1. Our own computers for calibration</li> <li>2. Another computer for data collection sponsored by Dr. Taylor, discussed with Deepa and Anton</li> </ol>	Use backup files in another computer	<ol style="list-style-type: none"> <li>1. Feb, 14</li> <li>2. Mar, 6</li> </ol>	<ol style="list-style-type: none"> <li>1. Feb,19<sup>th</sup> (Solved )</li> <li>2. Mar,12<sup>th</sup> (Solved)</li> </ol>
Two IMUs	Provided by Dr. Deepa Galaiya	Buy two new IMUs sponsored by Dr. Taylor, discussed with Anton	Feb, 14	Feb,19 (Solved)
IMU related software in Linux (Packages included <i>Lpms-imu</i> and <i>ndi_tracker_ros</i> )	Installation from <i>Galen-Trackers</i> GitLab with the help of Anton	In Windows, install <i>Lpms_control</i> Software	Feb,19	Feb,21 (Solved)
EM tracker for Calibration	Get the access to Mock OR	Optical Tracker	Feb, 19	Feb,21 (Solved)
Phantom study data	Deepa do mock surgery in Mock OR	With the help of graduate student	Mar,1	Mar,6 (Not start)
Actual surgery data	Get data from Samuel who is responsible for collecting actual surgery data in medical school	Do all the measurement in Mock OR	Mar,10	Mar,12 (Not start)
MATLAB for data analysis Dropbox for data saving	Installation	Python Google drive	Mar,1	Mar,6 (Solved)

# Management & Contribution

- Attend the group meeting with Dr. Taylor weekly
- Make appointments ahead of time and discuss with Deepa weekly
- Weekly meeting between Hanqing and Zhen every Monday evening
- Make appointments with Anton if needed

Hanqing and Zhen will do preparation work and the first data analysis together for the phantom study in Mock OR. When the real study in OR starts, we will do data analysis individually.

# Reading List

- Du, Y., Shih, C., Fan, S. et al. An IMU-compensated skeletal tracking system using Kinect for the upper limb. *Microsyst Technol* 24, 4317–4327 (2018).
- Islam, Tariqul, et al. "Comparison of complementary and Kalman filter based data fusion for attitude heading reference system." AIP Conference Proceedings. Vol. 1919. No. 1. AIP Publishing LLC, 2017.
- Won, Seong-hoon, William Melek, and Farid Golnaraghi. "Position and orientation estimation using Kalman filtering and particle filtering with one IMU and one position sensor." 2008 34th Annual Conference of IEEE Industrial Electronics. IEEE, 2008.
- Lakhiani C, Fisher SM, Janhofer DE, Song DH. Ergonomics in microsurgery. *J Surg Oncol*. 2018;118(5):840–844. doi:10.1002/jso.25197
- Vaisbuch Y, Aaron KA, Moore JM, et al. Ergonomic hazards in otolaryngology. *Laryngoscope*. 2019;129(2):370–376. doi:10.1002/lary.27496
- Wong K, Grundfast KM, Levi JR. Assessing work-related musculoskeletal symptoms among otolaryngology residents. *Am J Otolaryngol*. 2017;38(2):213–217. doi:10.1016/j.amjoto.2017.01.013
- Wang R, Liang Z, Zihni AM, Ray S, Awad MM. Which causes more ergonomic stress: Laparoscopic or open surgery?. *Surg Endosc*. 2017;31(8):3286–3290. doi:10.1007/s00464-016-5360-5
- Zihni AM, Cavallo JA, Ray S, Ohu I, Cho S, Awad MM. Ergonomic analysis of primary and assistant surgical roles. *J Surg Res*. 2016;203(2):301–305. doi:10.1016/j.jss.2016.03.058
- Nguyen NT, Ho HS, Smith WD, et al. An ergonomic evaluation of surgeons' axial skeletal and upper extremity movements during laparoscopic and open surgery. *Am J Surg*. 2001;182(6):720–724. doi:10.1016/s0002-9610(01)00801-7