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Dynamic Decision Making in Surgery

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By

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Lisa M. Kervin ENTITLED Dynamic Decision Making in Surgery BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT

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Following Dominguez (1997), we tested for differences among 10 resident surgeons' eye-scanning patterns during a laparoscopic cholecystectomy video. We measured time, number of fixations on anatomy and instruments, discomfort level ratings, notation of cystic artery, and conversion to open-incision. We expected our 10 residents would fall into two scanning strategies, proactive or reactive. Proactive strategists were defined as more skilled (year in residency, cases performed), anticipatory of danger (time and fixations on anatomy), observant of the pulsing cystic artery, and converting from laparoscopy to open when highly uncomfortable. Reactive strategists were expected to spend more time on instruments, have low discomfort ratings, not notice the pulsing cystic artery and not convert to open. Our results revealed increased time on anatomy positively correlated with year in residency and number of surgeries, suggesting that experience leads to proactive scanning strategy. Also, our residents were more uncomfortable than residents in Dominguez (1997).

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I. INTRODUCTION

Physicians take the Hippocratic Oath very seriously as they agree to abide by the law of "do no harm". What makes each surgeon perform surgery differently if they have the same objective in mind? Why does each surgeon have a different set of observations and concerns during the case? What level of risk is acceptable in relation to the first law of the Hippocratic Oath (Bosk, 1979)? How do some surgeons decide to question their "field of safe travel" within the abdomen and convert to an open-incision cholecystectomy after beginning the case laparoscopically? To gain a better understanding of this conversion decision, differences in 20 surgeons-specifically 10 attending (hospital staff surgeons) and 10 resident surgeons' decision making comments and scaled responses to questions were investigated by Dominguez (1997). The study examined the differences in decisions made by the surgeons in converting to open-incision surgery, while watching a difficult laparoscopic video. The study looked at how the surgeons approached the decision to convert to open-incision surgery by analyzing responses to a set of questions, Likert-scaled rating responses for comfort, risk and skill levels during the video, and comments (self-criticism) made by surgeons throughout the experiment. Their responses helped determine how metacognition (self-criticism which included metacognition and Likert-scaled responses to questions) interacted with expertise (their year in residency or practicing) in laparoscopy. Our experiment was closely modeled after Dominguez (1997) study in content, format and procedure. The motivation behind our study came about through questions raised by the Dominguez

(1997) study, specifically, “was something seen (or not seen) by surgeons that decide to convert to open?” Our study investigated eye movement and acknowledgement of the pulsing cystic artery made by resident surgeons, while watching the same laparoscopic video presented during the Dominguez (1997) study. Our study was designed to look at potential links and differences between metacognition (self-criticism and Likert-scaled comfort ratings), eye-scanning patterns and the decision to convert to open-incision surgery for resident surgeons.

Anatomical Understanding

Since a cholecystectomy is the removal of the gallbladder from within the upper abdominal area of the body, it is essential to understand the anatomy of the digestive tract in the region of the gallbladder. Known as the accessory organs, the liver, gallbladder and the pancreas are contained within the upper abdominal area of the body, below the rib cage. The liver courses the body left to right and front to back at that area, with the gallbladder at the midline along the bottom margin of the liver. The pancreas sits below the liver and the gallbladder area. The gallbladder appears sac-like with ductwork protruding superiorly and inferiorly. It is considered a non-essential hollow organ that concentrates and stores bile from the liver. The right and left hepatic ducts inferior to the liver merge to form the common hepatic duct, anterior to the gallbladder. Intertwined within that area are the cystic artery and cystic vein. The cystic duct branches from the neck of the gallbladder and channels bile in and out of the gallbladder. The point where the common hepatic duct from the liver and the cystic duct from the gallbladder merge is known as the common bile duct. The common bile duct attaches at the duodenum of the small intestines, where bile is deposited for digestion of fatty foods. Because of this direct connection, it is possible to live a healthy life without the gallbladder as long as the common bile duct remains intact.

Surgical Understanding

Since the introduction of minimally invasive surgical (MIS) technique into the United States (McSherry, 1989), a small tubular fiber-optic camera (endoscope), has been utilized in viewing real time images of many different anatomical areas. Endoscopy is re-named according to the area of interest, and an endoscope used for entrance through the abdominal peritoneal cavity is called a laparoscope, hence laparoscopy. In this type of surgery, the laparoscope is inserted into the abdomen through one of four small abdominal incisions with ports, strategically placed around the area of interest. The ports allow for the introduction of various surgical instruments after insufflation (the expansion of the abdominal cavity by injecting carbon dioxide gas) has occurred. A common use for the procedure has become the laparoscopic cholecystectomy, commonly known as gallbladder removal surgery. It is important to remember that a full evaluation of the patient condition such as: age, medical history, current health, blood work results, condition of the abdomen (cirrhosis of the liver, prior surgeries, distended gallbladder) must be considered before the surgeon decides on the modality of surgery- laparoscopic or open-incision technique. The process of a typical laparoscopic cholecystectomy, as revised by Dominguez (1997, p46) entails 10 steps: insufflation of the abdomen, survey anatomy, establish 3 other ports, grasp and retract gallbladder, identify cystic duct and artery, perform a cholangiogram if needed, clip and cut the cystic duct and cystic artery, separate the gallbladder from surrounding liver tissue, remove the gallbladder, and perform a final survey of the scene (Cooperman, 1992).

During a cholecystectomy, it is imperative to identify the cystic duct, cystic artery and the common bile duct. When the cystic artery is separated from surrounding tissue, it clearly pulsates allowing for positive identification. This is considered a key landmark within the gallbladder area. Once identification is obtained, there should be two items clipped and cut, the cystic duct and the pulsing cystic artery. The common bile duct should never be clipped and cut. Throughout a surgeon's training they are taught to convert to open-incision technique whenever there is anatomical uncertainty, doubt or increased concern for the patient's well being. Often times when the gallbladder is extremely infected, bloody and fragile, it is difficult to distinguish anatomical parts and identify the cystic duct, cystic artery and the common bile duct. When the scene is difficult to decipher, it is easy to make a mistake. At this point, good surgical understanding and honest self evaluation by the surgeon of one's abilities are imperative for knowing how to proceed with the case.

Understanding the Background Study

In an attempt to understand the conversion decision during laparoscopic procedures, Dominguez (1997) investigated surgical decision-making by 10 attending (hospital staff surgeons) and 10 resident (in surgical training) surgeons while watching a difficult laparoscopic cholecystectomy video (see procedure section for a description of the video case). For Dominguez, this naturalistic domain was the beginning point for scientific research in laparoscopic surgery. She was able to ask and investigate: what is a stimulus, what is a decision, where does cognition take place? From these basic theoretical underpinnings, she was able to look at the decision to convert to open-incision technique within the laparoscopic surgery domain by examining different approaches to the conversion decision by each surgeon. Behavioral variables that were considered important for analysis were: metacognitive (self criticism comments) and discomfort level ratings by surgeons, whether or not they converted to open-incision technique and whether or not the pulsing cystic artery was noted. The results of the experiment revealed the 20 surgeons classified into four distinct groups as a function of their level of experience (resident or attending surgeons), and their decision to convert to open-incision technique (whether or not they did at any point while viewing the video case). The study found that 9 surgeons decided to convert to an open-incision procedure during observation of the videocase. Utilizing a Likert-scale (1= no concern, 7= convert to open now), 5 residents with a mean comfort rating (MCR) = 6.4, and 4 attending with an MCR = 5.6, were noted. Only one surgeon from each of those groups commented on the pulsing artery. Eleven surgeons did not convert to open during observation of the videotape. Five residents with an MCR = 2.5, and 6 attending surgeons with an MCR = 4.7 were noted. For those non-openers respectively, 2 resident surgeons and 6 attending surgeons commented on the pulsing artery (Figure 1 represents these findings).

Dominguez (1997) summarized her findings and states that there were differences in judgment or perceptual skill among attending and resident surgeons. These differences led to different situational analyses for medical diagnoses and prognoses based on the discomfort level given by each surgeon at the various decision points. The amount of self-criticism, the average of the comfort levels, the decision to open or not, and identification of the pulsing artery were the determining factors. The level of discomfort and the awareness of potential dangers to the patient did influence some surgeons to convert to open. Her study was able to show that there is a difference in metacognitive comments between surgeons with varying levels of expertise and the decision to convert to an open-incision case. As a result, analysis of verbal comments from each of the staff and resident surgeons resulted in some understanding of how expertise and metacognition interact within the surgical domain for the final conclusions of that study.

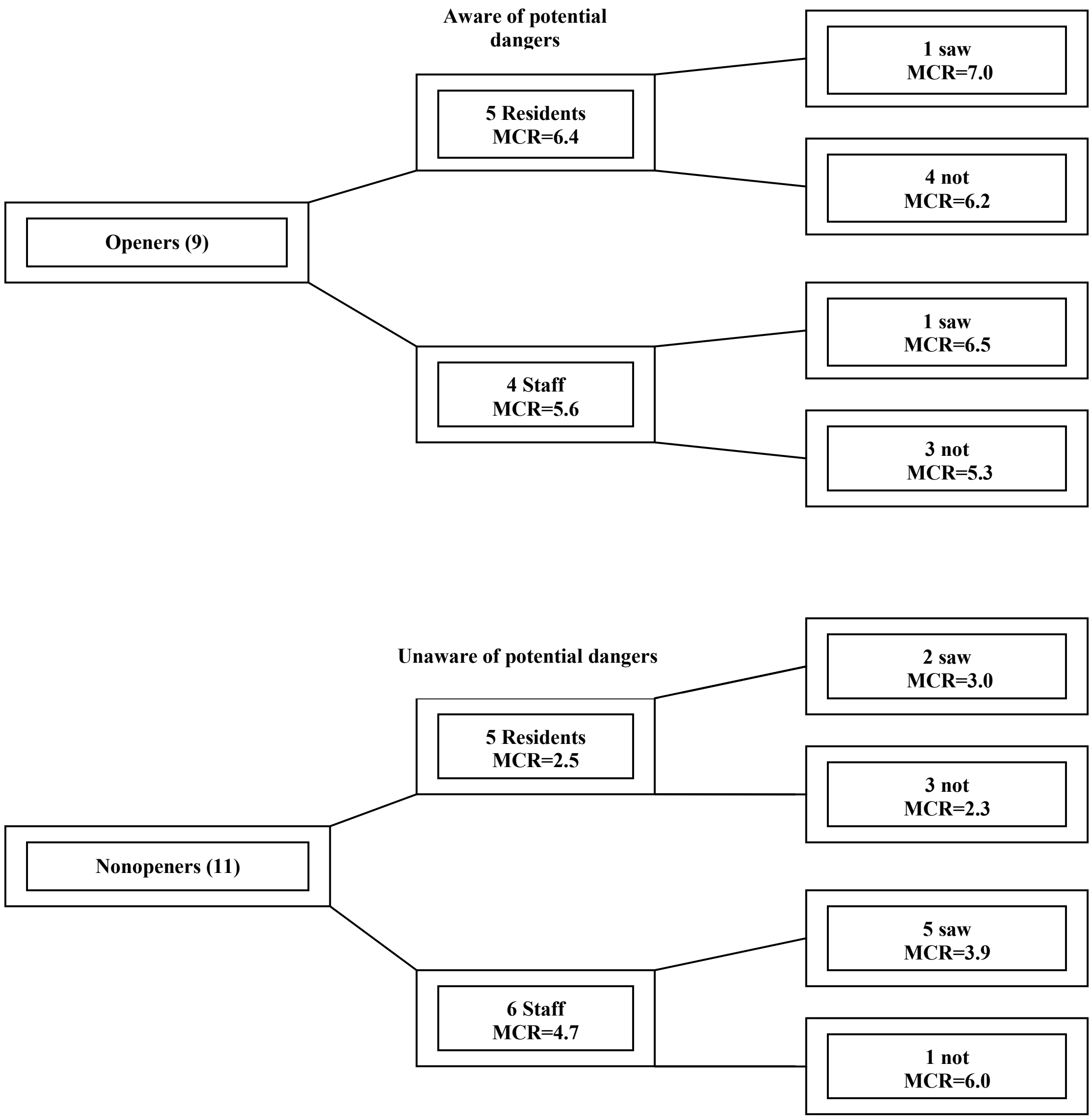

Figure 1. Dominguez's (1997) flow chart showing openers and nonopeners in subsets of attending and resident surgeons seeing the pulsating cystic artery or not. The number is the mean comfort level (MCR) at decision point 3.

Hypothesis

The conversion decision has been an increasing key concern in the medical community since the introduction of minimally invasive surgery (MIS). It remains unclear as to the degree to which reduced perceptual information influences the conversion decision during MIS. Greene (1995) stated: “the urge to follow through with an endoscopic approach may be so strong that judgment becomes clouded and the timing of the conversion process is, therefore delayed until an untoward event has occurred (knowingly or unknowingly).” Preoperative patient factors such as: obesity, age, gallbladder condition and laboratory results help to identify likely patients that may be involved in a conversion case (Rosen, Brody & Ponsky, 2002). Knowing these [patient] predictive factors helps to identify a time frame to continue laparoscopically, before converting to an open-incision cholecystectomy (Kama, Kologlu, Doganay, Reis, & Dolapci, 2001).

As the [patient] factors may facilitate how the surgeon will commence a surgical case, there are still questions about how and when the surgeon decides to convert to open-incision technique during a laparoscopic case. Identifying a surgeon’s comfort level on continuing a case with the laparoscopic technique, is paramount in understanding the conversion decision. Dominguez (1997) was able to investigate comfort levels of 10 attending and 10 resident surgeons at all levels of experience. The study found a connection between metacognition (self-criticism) and expertise. As a result, our study was designed to investigate the link between metacognition of 10 resident surgeons and their eye-scanning patterns, while viewing the same video used by Dominguez (1997). We felt there was a potential link to different eye scanning patterns and the year in residency for each resident. We were particularly interested in differences as a function of experience and as a function of whether resident surgeons detected important cues (cognitively speaking), such as the pulsing cystic artery. We also believed that the amount of time on an anatomy (gallbladder, liver, and blood), or instruments, would be indicative of a surgeon's level of experience. In our study, we proposed that we should see a distinct difference in eye-scanning patterns between surgical residents that commented they would convert to an open-incision surgery case (labeled "openers") and those that never commented they would convert to an open-incision surgery case (labeled "non-openers"). We suspected that the duration of time and number of fixations on the instruments and anatomy would be distinctly different between openers and non-openers. We specifically looked at whether or not the pulsing cystic artery was verbally identified by decision point three (Appendix E shows the timeline of the experiment), and the duration of time and number of fixations on the pulsing artery. We also investigated the resident's comfort, risk and skill levels at various decision points throughout the video, however, we were mainly concerned the comfort in out study. We anticipated we would be able to categorize resident surgeons into several different scanning strategies, of which we labeled as proactive or reactive strategies. Proactive strategists would be those spending more time on anatomy appearing to lead the instruments around the scene, likely noting the pulsing cystic artery and indicating a high discomfort level for continuing laparoscopically. Reactive strategists would be those spending more time on instruments, appearing to follow the instruments around the scene, unlikely to note the pulsing artery and revealing a low discomfort at continuing laparoscopically. We expected that different eye-scanning patterns between proactive and reactive strategists may parallel the differences that Dominguez (1997) observed in the metacognitive statements, and comfort level ratings of openers and non-openers of the more skilled and less skilled resident and attending surgeons in that study.

II. INVESTIGATING DYNAMIC DECISION MAKING IN SURGERY

Many different dynamic decision making domains have been investigated from a human factors perspective including: courtroom decisions, firefighting tactics, medical decision making, and specifically, surgical decisions related to converting from laparoscopic to open-incision technique. Often times, the theoretical decisions made by people during simulated events, may be different from the actual decision made during a real time event. It has been shown by Konecni, Ebbesen, & Hock (1996) that laboratory simulations of criminal sentencing decisions by judges and parole officers were different from decisions made in the actual courtroom setting. The differences in decisions made were associated with important variables being left out in the laboratory setting. How then should we study dynamic environments? Because investigating dynamic environments is very complex, it is important to look at the decision making process as close to the natural setting as possible, if not within the natural setting. But what characterizes naturalistic decision-making settings and how does the surgical domain fit into this? It has been found, according to Orasanu and Connolly (1993), that there are 8 typical factors that characterize naturalistic decision-making settings, of which the surgical domain fits into perfectly. These characteristics are: problems are ill-structured; there is uncertainty within dynamic environments; there are competing, ill-defined or shifting goals or norms; action/feedback loops are present; there are time stressors; stakes are high; multiple players usually are present; and there are organizational goals and norms to consider. From a surgical perspective, these characteristics apply within the surgical domain and are integrated in the decision making process. The first characteristic is that problems are ill-structured. Nothing within the surgical domain is clearly defined once the surgeon has entered the body cavity. The second characteristic is simply that the environment is uncertain, dynamic or changing. There are no specific lines indicating anatomy, nor any guarantee that known protocols will be applicable in such a dynamic environment. Again, the surgery may not go according to plan, with critical situations occurring such as rupturing the gallbladder, or cutting the common bile duct. The third characteristic is that there are ill-defined, shifting or competing goals within the surgical domain. The initial decision to begin the surgery as open-incision or laparoscopically, and the decision to continue the case as initiated, indicates there are shifting and competing goals as the surgeon proceeds utilizing laparoscopic or open-incision technique. The decision to minimize the effect on the integrity of the abdominal wall (by utilizing the laparoscopic technique) versus not harming the biliary structures (by utilizing the open-incision technique) is extremely important. The fourth factor refers to action/feedback loops which are present in decision making processes. Once the decision is made about the surgical technique to be employed, the resulting feedback provides information within the action/feedback loops. This additional information facilitates responsive actions as necessary, perpetuating more decisions within the loop, which in turn encourages more action/feedback until the issue is resolved. Stress is the fifth factor that becomes evident as the severity of a patient's condition, age and overall health affect the level of urgency to complete the case quickly. Generally speaking, the greater the urgency to complete the case, the greater the stress level. The sixth factor is the idea that the stakes are high within the surgical domain. As the condition of the patient worsens (along with other physiological factors), the likelihood of death under those circumstances increases. Because of the dangers present in any case, it is imperative that the many team members (surgeons, anesthesiologists, nursing and operating room staff, and radiologists and technicians) work together to orchestrate a successful surgery. These members are considered the multiple players in which Orasanu and Connolly (1993) refer to as the seventh factor. The eighth and final factor takes into account the overall political climate of the hospital and all of the policies enforced by the medical facility, covering a broad range from surgery scheduling to ethics. These policies are noted by Orasanu and Connolly (1993) as the organizational goals and norms, which may result in additional stress and pressure on the surgical staff and even in the decision-making process.

Historically, classical decision-making theory has looked at individual decisions for each specific domain. Naturalistic decision-making looks at the process of decision making from the perspective of experience and lessons learned from other problems, and how that knowledge is applied. Rasmussen (1976) has suggested that "associations based on experience [may lead to] leaps directly from one state of knowledge to another." This indicates that the solution to a problem may be solved in a holistic sense rather than specific solutions to specific problems. This is also the basis of the Recognition Primed Model (RCP) introduced by Klein (1989, 1993). Specifically, when we talk about dynamic decision making according to Dominguez (1997) and this study, we are referring to the decision to convert the surgical case from a laparoscopic to open-incision surgery case. Because of the uniqueness and the dynamic set of variables present in each surgery case, utilizing the naturalistic investigative technique minimizes the chance for forgotten variables. The presence of the eight characteristics of decision making within natural settings as noted by Orasanu and Connolly (1993) also indicates that the surgical domain should be studied as closely to the natural domain as possible (without compromising patient safety). By studying the domain, it may be possible to gain an understanding of how surgeons make the call to convert from laparoscopic to open-incision technique, potentially revealing the differences between attending and resident surgeons in what they are seeing, detecting and noting.

Perspectives of Surgical Domain

Today laparoscopy is known as the Gold Standard in the United States, because the number of cases performed laparoscopically has risen sharply since the 1980's. It has become the predominant surgical technique chosen by the surgeon when beginning or exploring for gallbladder removal surgery (Soper, Stockmann, Dunnegan, & Ashley, 1992). Laparoscopy has been chosen as the technique of choice for a variety of reasons both by the surgeons, as well as the patient. From the patient's perspective, there are several advantages for choosing laparoscopic over open-incision technique. The utilization of smaller incisions has reduced patient recovery time and cost (Dashow, Friedman, Kempner, Rudick & McSherry, 1991); in-hospital stays are shorter; and cosmetically, the scarring is less evident (Cooperman, 1992: Cushieri, 1995).

Physician Concerns

However from the physician's perspective, there is a conflict between reducing incision size, and reducing available perceptual information during surgery. The cystic artery carries the blood from the liver to the gallbladder, while the cystic duct carries bile from the common bile duct to the gallbladder. Both the cystic artery and the common bile duct present potential complications for the surgeons as gallbladder removal occurs. The common bile duct is attached to the liver and the small intestine. Bile is essential for proper digestion of the nutrients we take into our bodies. Therefore, during gallbladder removal surgery, it is essential to leave the common bile duct intact and to clip and cut the cystic duct and cystic artery. A reduction in perceptual information may make it difficult to identify the three imperative structures: the cystic artery, cystic duct and the common bile duct, even though insufflation is utilized to expand the surgeon's workable space, and field of view inside the body. Misidentification of these structures may subsequently lead to critical errors such as: cutting the common bile duct, lacerating the surrounding tissues, and increased chance of secondary infections. The reduction in perceptual information from within the body is not the only disadvantage for the surgeon. Unfortunately, the endoscopic TV feedback monitor from the laparoscope provides only monocular vision from within this reduced field of view. With the layout of the surgical suite set so that the endoscopic TV feedback monitor is on one side of the patient and the surgeon is on the other, there is an unusual mapping created between the hands and the monitor (Holden, Flach & Donchin, 1999). Because of the reduced information available to the surgeon, it is not uncommon for the surgeon to convert from laparoscopic to an open incision cholecystectomy as patient status, or perceptual information necessitates (Lichten, Redi, Zahalsky & Freidman, 2001). Serious complications can arise if the surgeon is not aware of risks, and patient condition as a result of choosing or continuing laparoscopic over open incision technique/performance.

Human Factors Psychology Issues

From a human factors psychology perspective, there are several things to consider when designing for laparoscopy such as: the physical ergonomics involved in instrument design and the layout of the surgery suite, the monoscopic visual perspectives presented on the endoscopic feedback and the x-ray monitors, the process of picking-up/detecting, perceiving and processing information, the resulting actions taken by the surgeon, and the overall evaluation of the effectiveness of surgical laparoscopic training.

Ergonomically speaking, the surgical instruments are very difficult to hold, use and manipulate. They are long handled with a trigger mechanism at the hand-held end and micro-sized tools at the other end. They are designed for insertion through the ports that have been placed in the abdomen. Monoscopic vision is a problem on the TV monitor used for viewing the laparoscopic images. All images are shown in color, but the image is 2-dimensional because of the screen. The utilization of the laparoscopic technique has reduced the tactile sense and visual field of view, as well as the range of movement available for the instruments. (Tendick, Jennings, Tharp, & Stark,1993). Another monitor problem is apparent with the C-arm (real time portable surgical x-ray machine) images produced during an ERCP (endoscopic retrograde choleangiopancreatography) fluoroscopic procedure. This procedure is not always utilized during a laparoscopic cholecystectomy, but when the surgeon is uncertain of structures, it may be employed to visualize the ducts from the liver to the gallbladder and the small intestines by injecting contrast medium. The images produced are in black and white as they represent the x-ray image of contrast medium flowing through the ducts. The anatomical scene on this monitor can be reversed and inverted if the technician has not set the monitor anatomically correct, causing a serious mapping problem for the surgeon. The two different monitors (endoscopic and x-ray) within the surgical suite, present a general perceptual mapping problem for all surgeons when switching from one to another if the images are not anatomically correct or the room is not set up correctly.

Historical Perspective: Experts and Novices

What the surgeon sees and if the surgeon sees imperative warning signs, are factors in evaluating patient condition before, during and after a surgical procedure. Evaluating a patient's condition is dependent on information pick-up/detected and experience by/of the physician. In order for information to be detected or picked-up, it must be perceived and processed in order to become an experience. Perception, as defined by Eleanor Gibson (1969), is the "process by which we obtain firsthand information about the world around us". She also described perceptual learning as "an increase in the ability to extract information from the environment, as a result of experience and practice with stimulation coming from it". James Gibson (1966) reminded us that the process of perceptual learning is not passive, but rather active as we explore and search the world, learning and adapting as stimuli are encountered, and even when not. Shore and Klein (1988) reported that perceptual learning occurs continually throughout life. Gibson & Gibson (1955), showed that perceptual learning is an increase in specific detection of properties, patterns and distinguishable features of stimuli (Gibson, 1966).

Intentional eye movements and scanning are the most important physical methods employed for patient information pick-up/detection. Eye movement research has shown eye scanning patterns develop as visual experiences increase throughout our lives. Mackworth and Bruner (1970) showed that children had shorter eye movements, restricting eye movements to high detail areas while avoiding the periphery. Visual search strategies were less successful than adult visual search strategies, and variable from child to child. Vurpillot (1968) found that younger children had fewer fixations on distinct portions of the drawings, and did not have a systematic sequence of comparisons between a pair of drawings. It was concluded that children have a limited scope in scanning due in part to their limited ability to process information at specific ages. In adults, Mackworth and Morandi (1967) found that saccadic eye movement usually followed outstanding areas of a picture, based on the high information or unpredictable content, and that these areas received the largest ratio of gazing. Yarbus (1967) showed the variability in viewing of a picture to be sustained over content areas, contour areas, and lightness and darkness patterns.

Classic research in perceptual learning of memory and visual search by Schneider and Shriffin (1977), and Shriffin and Schneider (1977) has revealed that one is influenced in current visual searches by prior visual search results. This indicates that perceptual learning of the target information is influenced by repeated search tasks, eventually reducing search time with increasing familiarity of the search task (Nakayama, Maljkovic, & Kristjansson, 2004; Rabbit, Cumming, Vyas, 1979). However, regardless of the degree to which a search task may become familiar, Fisk and Hodge (1992) noted the degree of difficulty of the search task also determines the amount of perceptual learning acquired, as well as the amount of time from introduction of the information to seeing it again. Ahissar and Hochstein (1997) found that repeated practice improved visual search results over time, but too, that task difficulty revealed the amount of perceptual learning achieved. Increased task difficulty revealed an increase in the specific learning, supporting the notion by Fisk and Hodge (1992) that objects intentionally searched out are more likely to be retained in memory than a non-specific object search. With the addition of color as the target, Donderi (1994) investigated visual acuity and color vision revealing that color vision accounted for about 40% of the detection rate of a specific target.

Clearly memory and attention play important roles in the human ability to execute specific actions. Neuroimaging today has shown us that there is a link between memory and attention functions resulting in specific behaviors stimulated by environmental conditions (Vroomen, Bertelson, de Gelder, 2001). The fire fighter is influenced by past experiences as he executes his next move without conscious thought (Klein, 1989), and surgeons appear to do the same. Patel and Groen (1991) pointed out the experts may be selectively choosing what is important to attend to. As introduced by Gibson & Crooks (1938), the “field of safe” travel is that pertaining to the space before a driver in a car that allows it to keep moving without hitting anything. Some surgeons seem to be able to move forward knowing their location within the body, with an awareness of limitations and potential dangers. Instrument design, visual perspective, and picking-up/detecting, perceiving and processing of information all contribute the effectiveness of surgical laparoscopic training and performance. It seems important to understand from a human factors perspective that these issues may influence how much and what a surgeon is learning during laparoscopy training, allowing for advances and improvement in teaching techniques.

As described above, it appears that eye movement and targeting specific information, increases as experience increases. Seeing all the pertinent perceptual information is imperative in the surgical decision to convert to open. However, some surgeons may not be seeing the pertinent information. Expert and novice differences have been described by de Groot (1966) in chess playing and, Chase and Simon (1973), as a difference in memory organization while playing chess. Chase and Simon found that experts and novices were no different in chess skill when presented with random plays, but experts outperformed in recall of positions over the novices when playing a real game of chess. Expert chess players seem to look at the overall board game rather than individual pieces. Patel et al. (1991) pointed out the differences between expert, novice and intermediate physicians may be linked to the ability of the expert to selectively choose what is important, thereby filtering out extraneous detail. When filtering occurs, time is not wasted on processing unimportant cues in the domain. Charness (1991) indicated that the expert chess player is not developed through book learning, but through experience and knowing what not to do. This literature suggests that a distinguishing characteristic of experts may be their ability to "see" meaningful aspects of a situation that go unnoticed by novices. Reingold, Charness, Pomplun and Stampe (2001) have shown that strong perceptual coding of information for the chess expert, led to fewer fixations on chess pieces overall, yet a higher proportion on individual chess pieces. This study indicates the advantage for chess experts may be in experience, gained through perceptual encoding of overall strategy. In aviation, dwell time on instruments was revealed by Bellenkes, Wiickens, and Kramer (1997) to be indicative of the pilot's level of expertise. All of these studies seem to indicate the experts spend more time looking at the overall scene, rather than a specific item.

Considering the topics of eye movements, perception, attention and differences, it appears that there is likely a gap in physician ability based on experience. Therefore, one would expect that expert physicians think and scan very differently from novice physicians. And so questions arise- what are the exact differences between expert and novice physicians? More specifically, is an expert physician seeing differently from a novice when performing surgery? What makes one physician decide to convert to open-incision and others not? Are some seeing the pulsing cystic artery and others not? Are eye movements attributable to these differences?

III. METHOD

Participants

All 10 participants were surgical residents of Wright State University's School of Medicine's Surgery Department. Participation was voluntary and anonymous classroom feedback will be provided for surgical training, as a result of our findings. Participants had backgrounds in diagnosing gallbladder problems, human anatomy, surgical equipment and varying levels of experience with laparoscopic cholecystectomy procedures both open and closed techniques.

Materials

The materials for our experiment were identical to those in the Dominguez (1997) study, with the inclusion of an EMR-8 eye-tracking device. This tracking device was a hat-mounted camera with an infrared eye reflector attached to a retractable arm for positioning about one inch anterior and caudally toward the eye. The arm did not obstruct the participant's field of view. The infrared reflector, when reflecting off the eye, allowed for tracking of the eye movement by presenting a crosshair on a 9 in. diagonal TV screen, while being recorded on a JVC video cassette recording device (VCR). The participants viewed the laparoscopic videocase on a 21 in. diagonal TV, with another JVC video cassette recording device attached to it. A sound mixer with headphones was utilized to monitor volume and sound conditions during the recording. A written consent form for participation in this experiment, as approved by the Institutional Review Board, was also provided to each participant. The original items utilized from the Dominguez (1997) study included: the videotaped surgical case of an 80 year-old patient's laparoscopic cholecystectomy (video description is below); a brief history (Appendix D) of the patient's condition; pre-video, video and post-video interview questions including three Likert-scaled questions. Pre-video questions were utilized to reveal concerns about patient condition, the adequacy of patient information being provided to the resident and the resident's perceived appropriateness for beginning the case laparoscopically. Questions during the video included the three Likert-scaled questions which were utilized by the participants to rank his or her comfort levels for continuing the case laparoscopically, the perceived level of risk associated with continuing laparoscopically and the perceived level of skill that was needed to continue the case laparoscopically. Other questions pertained to what each resident perceived as occurring while watching the videocase, and ways that he or she would perform the surgery differently. Post-video questions were identical to the video interview questions, and were followed by a brief discussion of potential patient complications (see Appendices A, B, C for the exact questions).

The video presented to the 10 residents was an approximate nine minute segment which began within the abdominal cavity after all ports were placed and insufflation occurred. The video initially showed the anatomy within the abdominal area of the gallbladder, clearly revealing yellow gangrenous tissue and gallbladder. By inserting various surgical instruments into the placed ports, the surgeon in the video pushed and attempted to pull the gallbladder tissue out of the way. Eventually, the imperative structures (gallbladder, cystic duct, cystic artery) were isolated even though the scene remained very bloody and difficult to decipher. Eventually the tissue was grasped, pulled and slowly removed revealing structures that were clipped and cut. However, there were three structures clipped and cut when there should only have been two. The video ended with a drain tube being placed within the abdominal area after removal of the gallbladder.

Procedure

Upon entering the experimental suite, a consent form was presented to each participant. After reviewing and signing the consent form, each participant was fitted with the hat-mounted eye-tracking device so that eye movements could be calibrated and recorded. Eye movements were recorded on VCR1 unit that was turned on and remained on throughout calibration and experiment. From that point, our experimental procedure was strictly modeled after the Dominguez (1997) study. After calibration, each participant read the background/patient history of an 80 year-old woman diagnosed with severe gallbladder disease (see Appendix D). Participants were encouraged to think aloud while role-playing as the attending surgeon during the experiment. The initial history was followed by pre-video interview questions. Upon completion of these questions, the participant then viewed the 20-minute video of the laparoscopic cholecystectomy case, intermixed with interview questions at preset stopping points that were part of the videotape (Appendix E shows the sequence of the preset stopping points). The video interview questions included Likert-scaled questions regarding the resident surgeon's perceived comfort, risk and skill levels associated with the case. Post video questions were asked upon completion of the videocase and also included the Likert-scaled questions identical to those used during the video interviews. Upon completion of the post-video interview, the eye-tracking device was removed and each participant was debriefed about the patient outcome and the experiment.

Coding and Analysis of Scan Patterns

Prior to our testing, the original 20 minute videocase of the 80 year-old woman diagnosed with severe gallbladder disease was divided into four viewing sections for ease of interviewing, consistent surgical information, and for coding/analysis purposes. The divisions of the sections were chosen at the natural cuts in the original videocase, which were a result of shortening the case duration during the Dominguez (1997) study. These divisions allowed for the creation of the preset stopping points in Appendix E, and are identical to the stops used by Dominguez (1997). The decision to convert to open incision technique, was to have been determined before decision point three in Appendix E, as this was the way the study was analyzed in Dominguez (1997).

The fourth section (approximately 9 minutes) of the video was determined by a chief surgeon to have imperative information requiring crucial decision making. The chief surgeon noted that the most important items for our research were the pulsing cystic artery and the instruments, and both of these categories were present in this segment of the tape. It is important to note that there were three structures clipped during this segment and the pulsing cystic artery was very evident. For eye-movement coding purposes, we surveyed and compiled a list of all anatomical parts (non-instruments): gallbladder, liver, fat, body fluid, and the biliary vessels (common bile duct, cystic duct and the pulsing cystic artery), as well as instruments visible throughout this section. We sub-categorized the above items into: gallbladder, pulsing artery, other (including liver, fat and fluids), instruments and noise (including blinks and off screen time).

Coding was achieved by reviewing the tape created by the participant viewing the videocase with the eye-tracker mounted on the head. For the entire 9-minute section, coding was done by watching each participant’s tape frame-by-frame, and recording the start and stop time as the eye tracker device fixated on each of the sub-categories. The completed time history was then entered into a computer spreadsheet designed to compile in real time.

IV. RESULTS

In order to better understand the conversion decision during surgery our study examined behaviors and judgments of surgical residents while viewing a video from a difficult laparoscopic cholecystectomy case. The variables that were considered were: discomfort level ratings (1 = no concern, 7 = highest concern open now, see Appendix A); experience (year in residency and cases done); the amount of time fixating on anatomy and instruments; the number of fixations on anatomy and instruments; whether the pulsing artery was identified; and whether there was a decision to convert to an open procedure. Likert-scaled results for risk and skill were also collected in our study, but were not used in comparison to Dominguez (1997).

Table 1 shows discomfort ratings as a function of whether the participants decided to open and whether they mentioned the pulsing cystic artery. Results are shown for our study which included only residents and for Dominguez (1997) which included both resident and attending surgeons. Participants fell within two main categories: openers and non-openers. Overall comparison of openers to non-openers showed there were three openers and seven non-openers in our study, while Dominguez (1997) had five resident and four attending surgeon openers, and five resident and six attending surgeon non-openers. Specific comfort rating values for both studies are presented in Figure 1. In general for both studies, participants who decided to convert to open were less comfortable than those who chose to complete the surgery by not converting to open incision technique. This can be seen most clearly in Figures 2 and 3 and is consistent with our expectations, since opening would be the appropriate response to high discomfort or uncertainty. One exception to this pattern is the relatively high level of discomfort reported by the one attending surgeon in Figure 2 who did not identify the pulsing artery and who did not choose to convert to open. This surgeon seemed to recognize that the situation was dangerous, yet persisted using the minimally invasive procedure. This behavior is termed in literature as a laparoscopic cowboy – a surgeon that continues confidently in surgery (perhaps unwisely) despite awareness of dangers.

Table 1.

Comparison of mean comfort ratings (MCR) for Kervin's 10 resident surgeons and Dominguez's (1997) 10 resident and 10 attending surgeons.

	Openers	**Non-Openers**
Pulsing Artery		
Kervin Residents	1 (5.0 MCR)	4 (3.2 MCR)
Dominguez Residents	1 (7.0 MCR)	2 (3.0 MCR)
Attendings	1 (6.5 MCR)	5 (3.9 MCR)
No Pulsing Artery		
Kervin Residents	2 (6.0 MCR)	3 (4.0 MCR)
Dominguez Residents	4 (6.2 MCR)	3 (2.3 MCR)
Attendings	3 (5.3 MCR)	1 (6.0 MCR)

The most surprising result is the low level of discomfort reported by three residents in Dominguez's (1997) study who did not identify the pulsing cystic artery and did not convert to open (Figure 2). This is particularly surprising when compared with the six attending surgeons who decided to continue with the minimally invasive technique (non-openers) in the same figure. Because of the resident's inexperience and failure to note the key anatomical structure-the pulsing cystic artery, it was expected that they would be more uncomfortable than the more experienced attending surgeons.

However, these inexperienced residents were much more comfortable than the more experienced attending surgeons. In contrast to the laparoscopic cowboy we have called this group, tenderfeet because they seemly continued naïvely with the minimally invasive technique, oblivious to any dangers.

The residents in our study also showed discomfort ratings that were lower than the attending surgeons in the Dominguez (1997) study, but not as low as the residents in the Dominguez (1997) study (Figure 2). Remembering that laparoscopic surgery was introduced into the US during the 1980's this might reflect a shift in abilities, attitudes, beliefs, and even technology available in the modern day surgery suite. Thus, the residents in our study were more comfortable than Dominguez's (1997) attending surgeons, but perhaps better tuned to the dangers than Dominguez's residents. However, no definitive conclusions can be drawn without a larger sample size, including updated data for attending surgeons.

In addition to potential changes in teaching methodologies, it is important to note from the above information that our residents seemed to be experiencing more cases earlier in their education. Does the year in residency affect what information is detected or is it the number of cases performed? In order to look at that information closer, we have evaluated eye movement data on all of our residents. We specifically wanted to know if there was a difference between upper and lower year resident surgeons in what they were observing and detecting within the scene. We believed that each resident could be placed into two groups based on experience, comfort level ratings, time on instruments, time on anatomy, and whether or not the pulsing cystic artery was noted. We achieved this by looking at the eye-movements (as specifically described below) of each resident surgeon in the study.

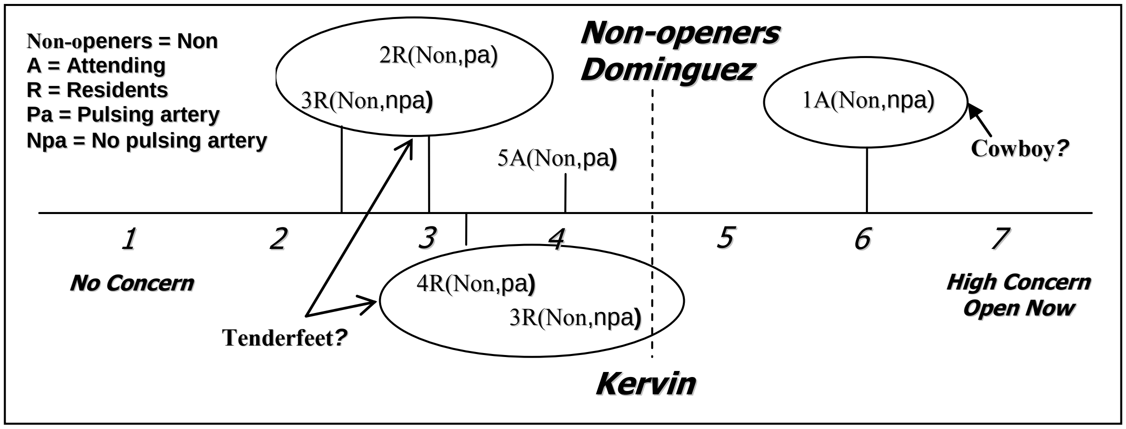

Figure 2. Comparison of mean comfort ratings for non-openers for Kervin and Dominguez (1997).

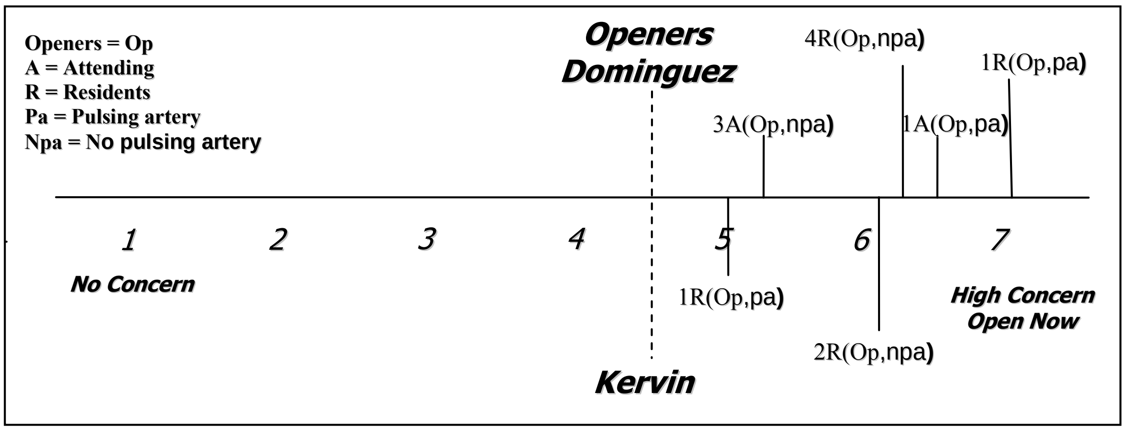

Figure 3. Comparison of mean comfort ratings for openers for Kervin and Dominguez (1997).

Tables 2 and 3 organize the data as a function of eye-movement patterns. As described in the methods section, each resident was fitted with the EMR eye-tracking device. All eye movements were recorded throughout the viewing of the entire case. A nine-minute section was coded for each participant so that eye movement data could be collected and compared. Coding involved recording time on the gallbladder, pulsing artery, other (including liver, fat and fluids), instruments and noise (including blinks and off screen time), frame by frame for each participant. The movements were integrated into three categories:

1. Noise – out of frame, blinks, etc.
2. Instrument – fixations on the action of the instruments
3. Anatomy – fixations on anatomy away from the instruments

A ratio was computed for both the proportion of time and fixations on the anatomy relative to the total productive (non-noise) viewing time [e.g., Time on Anatomy/(Time on Anatomy + Time on Instruments)]. The general hypothesis was that more experienced residents would adopt a proactive strategy with eye-movements that led the instruments in order to anticipate potential dangers. Whereas, less experienced residents would adopt a more reactive strategy in which eye-movements followed the instruments. Thus, the ratios for the proactive strategy should be larger, indicating a larger portion of the time on the anatomy, rather than following the instruments. The data in Tables 2 and 3 are sorted according to the value of this ratio and the bold line divides the data into two equal samples as the median split with the top half being more proactive than the bottom half.

Table 2.

Proportion of time on anatomy for surgery residents

Sub	Prop TA/ta+I	Pa v npa	# fix on pa	Op v cl	MCR d3	Yr resid	# surgeries
1	0.82	pa	16	cl	3.00	3	101
3	0.71	npa	15	cl	5.00	4	150
7	0.69	npa	7	o	7.00	2	30
9	0.61	pa	1	cl	3.00	3	60
12	0.54	pa	1	cl	4.00	3	51
4	0.52	npa	4	cl	4.00	2	13
11	0.51	pa	13	o	5.00	3	100
8	0.50	npa	7	cl	3.00	1	3
2	0.47	pa	13	cl	3.00	1	0
6	0.44	npa	5	o	5.00	1	20

It was hypothesized that residents using a proactive strategy would be more likely to note the pulsing artery. However, as can be seen in Tables 2 and 3 there was no difference. Using the time measure in Table 2, three out of five residents in the proactive area noted the pulsing artery and two out of five residents in the reactive area noted the pulsing artery. Using the fixation measure in Table 3, two out of five residents in the proactive area noted the pulsing artery and three out of five residents in the reactive area noted it. Also, there was no difference with respect to the conversion decision. Only three residents decided to convert to an open procedure. For either measure (time and number of fixations in Tables 2 and 3) only one of the residents in the proactive areas chose to open.

Table 3.

Proportion of fixations on anatomy for resident surgeons

Sub	Prop #fix anat	Pa v npa	# fix on pa	Op v cl	MCR d3	Yr resid	# surgeries
1	0.78	pa	16	cl	3.00	3	101
7	0.68	npa	7	o	7.00	2	30
4	0.65	npa	4	cl	4.00	2	13
2	0.61	pa	13	cl	3.00	1	0
3	0.59	npa	15	cl	5.00	4	150
9	0.57	pa	1	cl	3.00	3	60
11	0.56	pa	13	o	5.00	3	100
8	0.54	npa	7	cl	3.00	1	3
6	0.53	npa	5	o	5.00	1	20
12	0.53	pa	1	cl	4.00	3	51

Table 4 shows the correlations among the proportion time on anatomy, proportion fixations on anatomy, the comfort rating at decision point 3, the number of years in residency, and the number of prior surgeries. Not surprisingly, there was a positive correlation for proportion of time on anatomy and proportion of fixations on anatomy. We also found that increased time on anatomy was positively correlated with the number of years in residency and with the number of surgeries suggesting that experience leads to a more proactive scanning strategy. This was consistent with our original hypothesis. There was no relation between either experience (years in residency or number of surgeries) or scanning patterns (time or fixations) and comfort level ratings. Paired t-tests and Chi-squared analyses were performed on all data, but there were no significant findings noted.

Table 4.

Intercorrelations Among Continuous Variables

Variable	M	SD	Prop TOA	Prop FOA	Comfort	Year	Number Surgeries
% Time on Anat	.58	.12		r = .75*	r = .12	r = .64*	r = .65*
% Fix on Anat	.60	.07			r = .01	r = .17	r = .19
Comfort	4.2	1.31				r = .11	r = .15
Year	2.3	1.05					r = .90**
# Surgeries	52.8	50.00					

Note. *N* = 10. **p* <.05. ***p*<.01. Prop TOA = Proportion of time on anatomy. Prop FOA = Proportion of fixations on anatomy. Comfort = comfort rating at decision point 3. Year = Year in residency. Number surgeries = Number of surgeries performed by residents.

Overall, there seems to be some support for our hypothesis that more experienced surgeons will adopt a more proactive scanning strategy. However, there is no evidence that this strategy affected the difference in comfort level or an increased likelihood of noting the pulsing cystic artery. In comparison to Dominguez's (1997) results, this trend suggests that the residents in our study were more aware of the dangers (less comfortable) than the residents in her study. However, our residents still remained more comfortable than the experienced attending surgeons in Dominguez's (1997) study.

V. DISCUSSION

Since the introduction of laparoscopic technology into the US during the 1980's, the overall training of resident surgeons has changed regarding the technique initially employed for most surgical cases. Laparoscopy is now the preferred choice in most surgical procedures due to decreased time, money and recovery reasons. In our study, we found that our resident non-openers, not noting the pulsing cystic artery, were more uncomfortable than the same residents in Dominguez (1997) study. However, our residents were still less uncomfortable than the attending surgeons in that study. I believe this change in comfort level rating from 1997 to 2007 is an indication of the shift in teaching methodologies today. Because residents are taught to proceed laparoscopically when appropriate, there is less fear than 10 years ago. Obviously this has negative and positive implications. The resident will be more likely to tolerate what would have been considered intolerable conditions to continue laparoscopically, because of the belief that this is the way it is to be done. On the other hand, new advances in technology and laparoscopic techniques will mostly likely come about reducing the potential for error and surgeon discomfort in the years to come.

However, even with the above in mind, we set out to see if there were differences in eye scanning strategies between years in residency. Did the more experienced look at the scene differently than the less experienced? Were they leading or following the instruments? How much time did they spend looking at the anatomy versus the instruments? And what year in residency were they? As indicated earlier, we noted that the more experienced residents were looking at the anatomy more than the instruments, seeming to lead the instrument throughout the surgical field. We saw that the increase in time on anatomy was positively correlated with the number of years in residency and the number of surgeries performed. Half of the residents noted the pulsing artery while some opened and some did not. On the other hand, some of less experienced residents spent more time looking at the instruments and less time observing the anatomy while not necessarily noting danger. We did not find any significant relation between years in residency, number or surgeries or time on fixations and comfort level ratings. This could be a direct result of the small sample size used for this study. In the future, it would be of interest to study a larger resident surgeon sample to further investigate the significance to the above categories, as well as re-evaluating attending surgeons. Since there has been more training in laparoscopy in the past years, and more usage by the attending surgeons, there may be more of a relation to the number of fixations on anatomy and noting the pulsing artery, while not converting to an open procedure.

These findings are important for the methodology utilized in training resident surgeons. Perhaps there is a more specific way to train the eye scanning strategy into the resident, while teaching the underlying knowledge necessary for each resident to perform the surgery. Even more importantly, there could be a method for the attending surgeons to teach from specifically, unifying teaching methodologies across the board. In general, class work is fairly uniform across all schools, but the methodology in the surgical suite varies as much as the number of attending surgeons teaching. They are trained in a more apprentice-like method. Dominguez (1997) discussed adding the videotape portion to a teaching curriculum, and I propose that adding the element of eye-scanning devices and analysis of eye-scanning patterns during video training could help point out each resident's area of weakness. Additionally, increasing observational skills through specific visual training prior to surgery rotations would be beneficial. In this time of acute awareness to patient safety, having a fully pre-trained resident surgeon is absolutely paramount. Being armed with the knowledge that there are differences in eye-scanning strategies between resident and attending surgeons, may help each resident learn more quickly and be more accurate with his/her decision-making. Since we are striving for less patient recovery time, less cost for surgery and less medical errors, then we should strive to provide more knowledge for the surgeon to make very informed decisions.

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APPENDIX A

Pre-Video Questions

1. What other patient information would you need before proceeding?

2. How would that information influence your decisions?

3. Would you even attempt to perform a laparoscopic cholecystectomy on this patient?

4. Please rate your comfort rating level at beginning or continuing this case laparoscopically

    1. No concern whatsoever
    2. Little concerns
    3. Increased concerns
    4. Moderate concerns
    5. Many concerns
    6. Very seriously considering beginning as open
    7. Would begin as open now

5. Please rate the risk of laparoscopic surgery at this point.

    1. No risks
    2. Little risks
    3. Increased risks
    4. Moderate risks
    5. Many risks
    6. Very seriously risks
    7. Would convert now/ extremely risky

6. Please rate the skill level you think is necessary at this point.

    1. No skill whatsoever
    2. Little skill
    3. Increased skill
    4. Moderate skill
    5. More skill
    6. Very serious skill
    7. Extreme skill

7. Would you do anything different procedurally than you would normally do?

8. If the surgeon decided not to begin this case laparoscopically, would you think that was a reasonable decision?

APPENDIX B

Video Questions:

Interview questions to be asked throughout the viewing of the videotaped laparoscopy.

1. What do you think is going on here?

(a) Are there any alternative interpretations you could make?

2. Do you have any concerns at this time? What are they?

3. What errors would an inexperienced surgeon be likely to make in this situation? Are there cues they might miss?

4. (If not generated spontaneously) Can you think of a time in your previous experience where you faced a similar situation?

5. Can you give me a numerical rating from 1 to 7 of your comfort level continuing with this procedure laparoscopically using the anchored scale shown here?

6. Can you give me a numerical rating from 1 to 7 of the skill level you think would be needed to complete this procedure laparoscopically, based on the anchored scale shown here.

7. Can you give me a numerical rating from 1 to 7 of what you think the risk level is at this point in the procedure, based on the anchored scale shown here.

8. If I told you that the surgeon "decided to open at this point" or "decided to begin this procedure as an open one", would you think that was a reasonable course of action?

9. Given that your overall goal is to take this gallbladder out safely, what are your current short-term objectives at this time?

10. (a) Are there any alternative courses of action which might work?

(b) Would you do anything differently than these surgeons are doing?

11. Are there any other cues you see that are influencing your actions that you haven't mentioned yet?

(a)Are there cues that you expect to see that are not present?

(b)As the attending surgeon, are you satisfied that the structures have been identified?

APPENDIX C

Post Video Questions:

Interview questions to be asked at the end of the videotaped laparoscopy.

1. What do you think is going on here?

    (a) Are there any alternative interpretations you could make?

2. Do you have any concerns at this time? What are they?

3. What errors would an inexperienced surgeon be likely to make in this situation? Are there cues they might miss?

4. (If not generated spontaneously) Can you think of a time in your previous experience where you faced a similar situation?

5. Can you give me a numerical rating from 1 to 7 of your comfort level continuing with this procedure laparoscopically using the anchored scale shown here?

6. Can you give me a numerical rating from 1 to 7 of the skill level you think would be needed to complete this procedure laparoscopically, based on the anchored scale shown here.

7. Can you give me a numerical rating from 1 to 7 of what you think the risk level is at this point in the procedure, based on the anchored scale shown here.

8. If I told you that the surgeon "decided to open at this point" or "decided to begin this procedure as an open one", would you think that was a reasonable course of action?

9. Given that your overall goal is to take this gallbladder out safely, what are your current short-term objectives at this time?

10. (a) Are there any alternative courses of action which might work?

    (b) Would you do anything differently than these surgeons are doing?

11. Are there any other cues you see that are influencing your actions that you haven't mentioned yet?

    (a)Are there cues that you expect to see that are not present?

    (b)As the attending surgeon, are you satisfied that the structures have been identified?

APPENDIX D

Background/Patient History

Minimally invasive surgery presents both advantages and disadvantages to a patient. On one hand, damage to healthy tissue is reduced and the recovery period is shorter. On the other hand, the surgeon is handicapped by diminished perceptual information, increasing the probability that errors will occur (e.g. damaging or cutting the common bile duct while conducting a laparoscopic cholecystectomy). During laparoscopic surgery, assessing which patients will be converted to a fully invasive open-incision surgical technique is a continuous process that each surgeon undergoes throughout the surgery case. Converting to an open-incision surgery widens the scope and quality of perceptual information available by providing direct access to the operative area. In the dissertation by Dominguez (1997), "First Do No Harm: Expertise and Metacognition in Laparoscopic Surgery", she examined the decision to convert to open-incision full invasive surgery during laparoscopy. She also looked at the differences between attending and resident surgeons in how they approached the decision to convert to open-incision full invasive surgery. Verbal protocols were considered for the surgeons in both categories- resident and attending, helping to understand how metacognition interacts with expertise in laparoscopy.

You will be shown a videotape of three laparoscopic cholecystectomies. We ask that you "think aloud" during this case and comment on what you would be thinking if you were in control of this case (as either the primary surgeon or the supervising attendant). Periodically we will stop the tape and ask you questions. This patient is an 80-year old female with a 2-day history of fever and pain in the right upper quadrant

(RUQ) with a high white cell count. The ultrasound showed a distended gallbladder with a thickened wall and gallstones. Pericholecystic fluid was also found. We will now ask you a few questions.

APPENDIX E

Timeline for questioning/decision points within experimental video

Before video watching:

- Prevideo questions
- Initial Ratings
  - Comfort/risk/skill ratings
- Prevideo questions (Appendix A)

Commence video watching:

- Initial visualization of gallbladder
- Video stopped
- Decision Point 1
  - Comfort/risk/skill ratings
- Questions (Appendix B)

Continue video watching:

- After aspiration of tightly swollen gallbladder
- Video stopped
- Decision Point 2
  - Comfort//risk/skill ratings
- Questions (Appendix B)

Continue video watching:

- 1st structures- lymphatic identification
- Gallbladder ruptures
- 2nd structure- pulsing cystic artery identification
- Video stopped
- Decision Point 3
  - Comfort/risk/skill ratings
- Questions (Appendix B)

Continue videowatching:

- Completion of video
- Video stopped
- Decision Point 4
  - Comfort/risk/skill ratings
- Post video questions (Appendix C)