General introduction

Since the dawn of civilization, physicians around the globe have been captivated by the possibility of visualizing human's concealed body cavities. From the first ever documented endoscopic inspection of an internal organ by Arabian physician Abu al-Qasim (936-1013 CE), followed by Avicenna's (980-1037) fundamental addition of reflective light to the method, it has taken generations before the framework of modern endoscopy was built.[1,2] It's origin however, can be traced back to the industrial revolution and the technical advancements made in that era, which paved the way for the rapid innovation we have witnessed in endoscopic surgery so far. It was not until the year 1901 that the first endoscopic visualization of the peritoneal cavity was performed by Dresden based surgeon and gastroenterologist Georg Kelling (1866–1945), dubbing the procedure as "*koelioscopie*" (derived from Ancient Greek: *κοιλιά*, meaning "abdomen", and *σκοπέω* meaning "to see").[3] The presently more common name for this technique "*laparoscopy*" (of which the first part is derived from the Ancient Greek word *λαπάρα*, meaning 'flank' or 'side') was coined by his Swedish contemporary Hans Christian Jakobæus.[4] From that moment on, endoscopy has increasingly been used for diagnostic and later on also therapeutic purposes.

Still, performing endoscopic surgery in those days was an awkward and uncomfortable task, given the fact that the procedure had to be carried out by directly peering through the endoscope's eyepiece whilst passing verbal instructions, often ineffectively, to the operating assistant burdened with the task of blindly navigating the surgeon's field of view. To address this problem, several surgeons experimented with the use of video cameras – often intended for commercial use – combining these with their endoscopy equipment on their own initiative. The first in this regard to mention the two together was George Berci in his 1962 article "*Endoscopy and television*".[5] The main focus of his research however, was to provide improved documentation methods and novel teaching capabilities, not necessarily to alter the mode of operation. The first to recognize not only the physical constraints of this traditional approach, but also its impedance in performing more advanced surgical procedures, was Camran Nezhat. From the late 1970's and onward, Nezhat started to routinely perform laparoscopic procedures directly from a video monitor.[6,7] However, like the pioneers of endoscopy during its implementation encountered resistance amongst their peers, Nezhat faced the same fate as his predecessors in his transition to performing endoscopic surgery "*off the monitor*". Nevertheless, many physicians eventually embraced the possibilities of this method, preluding the mass implementation of endoscopic surgery we know today.

In the 1980's, the endoscopic revolution started to take form. Gynecologist Kurt Semm, by many considered as the father of modern endoscopic surgery, invented the automatic electronic insufflator and further developed endocoagulation.[8] In 1980, he performed the first laparoscopic appendectomy, after which he was subject to outrage from both surgeons and gynecologists. Surgeon Erich Mühe however was fascinated by Semm's technique, not affronted by it, as the rest of his colleagues were. Using Semm's instruments and technique, Erich Mühe perfomed the first laparoscopic cholecystectomy in 1985.[9] Shortly after in 1987,

Philippe Mouret performed the first ever *video-assisted* laparoscopic cholecystectomy.[10] These events prelude the drastic increase in procedures using a minimally invasive method, with laparoscopic cholecystectomy as prime example; a mere five years after introduction, approximately three quarters of all cholecystectomy cases were performed using a minimally invasive approach.[11-13] Due to this rapid increase, a large number of surgeons found themselves in unchartered waters. Formal training was not yet widely available and the transition from open surgery proved difficult for many.[14] This became particularly apparent in the incidence of one of the most dreaded complications of cholecystectomy: bile duct injury. In the first few years, the incidence of this potentially life-threatening complication rose significantly among patients operated by this method, with reports suggesting a two- to four-fold increase compared to the traditional open cholecystectomy.[15-20] However, as operator experience and cumulative case load increased, the incidence of BDI remained high.[21-23] Therefore, a common explanation for this problem has become that misidentification of biliary structures, rather than the novelty of the approach, is the major cause of biliary injury in laparoscopic cholecystectomy. Specifically local operative risk factors, e.g. active or chronic cholecystitis and obesity, as well as the presence of aberrant anatomy, might engender the operator to misinterpret the biliary structures, potentially causing erroneous clipping and transection of a major bile duct.[24] In an attempt to correctly identify the cystic duct, surgeons started using a technique later dubbed as '*infundibular technique*'. The essence of this technique is that a ductal structure is identified as the cystic duct by visualizing the traditional '*flare*' or '*funnel*' shape at the junction of the gallbladder infundibulum and the cystic duct. This technique was popularized because of the need of identification measures, as fundus first resection traditionally done in open cholecystectomy – in which the cystic duct is exposed by the natural flow of the surgery – was awkward to perform in a laparoscopic approach. However, this technique has been judged to be a hazardous method of identifying the cystic duct.[25]

It was not until 1995 that an anatomically well-defined method was introduced in response to the drastic increase of bile duct injury and the immense morbidity that accompanies it. In their critical review of the problem, Strasberg et al. proposed a number of criteria to abide by in order to decisively identify the structures entering the gallbladder.[26,27] No structure should be transected before that. The moment of this conclusive identification was dubbed as "*the critical view of safety*". In order to reach the critical view of safety, one has to achieve the following: 1) Calot's hepatobiliary triangle must be dissected free of fat, fibrous, and areolar tissue (it does not require the common bile duct to be exposed). 2) The lower end of the gallbladder must be dissected off the liver bed. 3) Only two structures should be seen entering the gallbladder. Being a crucial step in the procedure, it has been recommended by the Association of Surgeons of the Netherlands (*Nederlandse Vereniging voor Heelkunde - NVvH*), as well by the Society of American Gastrointestinal and Endoscopic Surgeons (*SAGES*) in the United States of America, to record the critical view of safety on photo or video before

transection of structures.[28,29] This way, it is properly documented whether the identification of structures was indeed decisive.

For years, creating a photographic record of an operative event, rather than a videographic one, had been the most feasible method. This despite the fact that videographic representation is significantly superior to its photographic or written counterparts.[30-32] For a long time, the main reason for this has been that a photograph took fewer actions to create and was easier to implement in the patient record. The last decade however have seen many technical advancements, along with hospitals making the switch from paper-based to electronic patient records. Because of this, video documentation has become less challenging to accomplish, prompting a whole new dimension in research focussing on education and quality of care.

A major benefit of intraoperative video documentation is the fact that it provides an objective source of technical procedural information, especially in endoscopic surgery, as the video is a one on one representation of the surgeon's vision during the procedure. This in contrast to the currently implemented method of operative reporting by way of the narrative, i.e. written or dictated, operative report. This source is, by definition, subjective and proved to be lacking necessary information on a regular basis.[32] A different method of improving the flaws of the traditional narrative operative report is the synoptic operative report. With a synoptic operative report a concise summarization of the surgical procedure is made using predefined leading criteria, which can be produced with ease using a computerized template. Furthermore, by the addition of quality of care indicators in this reporting method, these factors can be monitored efficiently, avoiding the need for double entry in a separate report.

An excellent example of what video can provide for quality improvement in surgery is the study conducted by the Michigan Bariatric Surgery Collaborative.[33] using peer-rated procedural video of laparoscopic gastric bypass surgery to assess participating bariatric surgeons' technical skills, the authors demonstrated the relationship between technical skills and postoperative outcomes. Overall, the study determined that greater technical skills do indeed result in significantly fewer postoperative complications.

Taking it a step further, Theodor Grantcharov, professor of surgery at the University of Toronto, wanted to initiate a switch from the traditional "reactive" management of adverse events, to a "proactive" approach. In order to achieve this, he developed the surgical 'black box'. Like its namesake in aviation, this recording device registers multiple inputs, i.e. sound (speech), videos from several angles (surgical site and surroundings), and patient's vital signs. This is all recorded in real-time over the course of the surgical procedure.[34]

Outline of this thesis

The aim of this thesis is to evaluate the main quality factors in abdominal surgery, in particular laparoscopic colorectal surgery and laparoscopic cholecystectomy, that could be enhanced by use of intraoperative video and audio recording and investigate barriers for implementation. It consist of three parts:

In Part 1, different modalities of multimedia recording and subsequent utilization are delineated.

In Part 2, the use of intraoperative systematic video recording for quality assurance in colorectal cancer surgery is covered.

In Part 3, quality and safety methods for laparoscopic cholecystectomy and notably the relevance of intraoperative systematic video and audio recording are reported.

PART 1 – Multimedia as a quality improvement tool in surgery

Chapter 2 provides an overview of the several advantages, as well as some significant barriers in medico-legal, ethical and technical fields. Due address the fact that many surgical parameters deemed important by surgical practitioners are omitted or inaccurately represented in the traditional operative report, synoptic operative reporting might be of assistance.

In **Chapter 3** a systematic review comparing the synoptic operative report with the narrative operative report in surgical treatment is reported. Despite the rapid developments in video recording in the operation room, the views of medical professionals having to deal with this have been poorly know.

In **Chapter 4** the results of a nationwide survey of these key players regarding the use of intraoperative multimedia recording are presented.

In **Chapter 5** the effects of segmentation in video-based learning of a surgical procedure (i.e. open inguinal hernia repair) are assessed.

PART 2 – Quality assurance in colorectal cancer surgery

In **Chapters 6 and 7**, the added value of intraoperative systematic video recording in laparoscopic colorectal cancer surgery are reported in a pilot study and a subsequent multicenter, prospective, observational cohort study, respectively.

PART 3 – Quality and safety in laparoscopic cholecystectomy

Chapter 8 provides a comprehensive review on several methods of bile duct visualization to reduce the most dreaded complication in laparoscopic cholecystectomy: bile duct injury.

In **Chapter 9** the results of a nationwide survey among surgeons and residents in training are reported regarding their current methods of executing laparoscopic cholecystectomy and their knowledge regarding the critical view of safety method in this procedure.

For **chapter 10 and 11**, the roles of intra-operative audio and video recording in terms of operative reporting are defined.

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