General discussion and future perspectives

We live in a time where great feats in surgical quality have been accomplished. In the treatment of colorectal cancer for instance, a disease of which surgical treatment remains the hallmark of its cure, 5-year survival rates of colorectal cancer has risen by tens of percentage, and the incidence has decreased due to preventive measures.[1,2]. Furthermore, since the introduction of the minimally invasive approach for several types of surgery, a drastic improvement of short- and long-term postoperative morbidity has been noted, without making concessions to surgical results or oncological outcomes.[3-5]

Despite these positive developments, a variability remains concerning the quality of surgical treatment, perhaps the most considerable factor in short- and long-term outcomes. This variability is evident in several types of surgery. For instance in colorectal cancer surgery, postoperative mortality and morbidity ranges from 0.5% to 6% and 15% to 25%, respectively.[3,6-8] In terms of oncological outcomes, disease recurrence ranges from 5% to 50% of patients and 5-year survival rates differing from 32% to 64%.[9-12]. Also a most evident variability is found among the incidence of bile duct injury in laparoscopic cholecystectomy, ranging from as low as 0.08% up to 0.40%.[13-17] The importance of quality assurance to reduce surgical variability is recognized and several quality improvement programs have already been established, such as the implementation of the surgical safety checklist used in the time-out procedure, effectively reducing perioperative mortality,[18,19] and the establishment of national registries and audits (e.g. National Program of Cancer Registries (NPCR) in the United States of America, the National Cancer Registration and Analysis Service (NCRAS) in the United Kingdom and the Dutch Institute for Clinical Auditing (DICA) in the Netherlands).

These registries and audits however merely focus on outcomes of surgery, not on the source of surgical shortcomings leading to decline in quality or potentially substandard care. Outside the often secluded faction of medical practitioners an increasing number of sectors are utilizing multimedia recording for their benefit in quality improvement and assurance. For instance in aviation, the black box records all flight data and communication in real-time during flight for use of accident and incident investigation. However, explicit directions and a chain of command are provided to comply with privacy law and prohibit misuse.[20] Recently in the Netherlands, after an initial small-scale trial period, formal recommendation have been made to the Dutch justice department and Dutch police force to expand roll-out of officer-worn body cams. [21] If other non-medical branches are embracing this novel technology, why not a cutting edge sector as medicine, surgery in particular? The main reason are the barriers that exist before a such a technology with a profound impact could be implemented. These barriers not only contain privacy issues for both medical professionals and patients, but also the technological (i.e. acquisition of hardware and storage) and legal restraints that come with this technology.

The fact remains that the current method of operative reporting is most often not adequate: essential information is frequently omitted or wrongly reported.[22] A possible aid to improve this might be the use of synoptic operative reporting. In **Chapter 3** we reported

that synoptic reporting does indeed add in the overall completeness of operative reports, however its use is far from general and a typical synoptic operative report heavily relies on a routine procedure and deviations during surgery are difficult to report in an easy manner and often time consuming. Furthermore, most synoptic reporting methods currently available compile a form upon completion which is, as the name describes, a condensed rundown of the procedure, with all essential information neatly listed in order, yet difficult to interpret in context due to the lack of narrative. A great asset of the synoptic operative report however is the fact that certain mandatory parameters necessary to complete the plethora of clinical audits and national registries could be entered just once, averting the necessity of duplicate registering and in the end saving time. For best effect, combining the readability of the narrative operative report and the accuracy of the synoptic report, a narrative form of synoptic reporting should be developed.

So what are barriers for use of multimedia recording in the operating as considered by end users, being the medical professionals? Our cross-sectional survey among medical professionals from several surgical specialties reported in **Chapter 4** reflects that the current surgical landscape is still divided regarding their readiness for intraoperative video recording. Numerous surgeons are accustomed to intraoperative video recording, as it is readily available in general and most agree it caters to an important element of being a medical professional: accountability. Many surgeons indeed do not oppose transparency. However, for a lot of surgeons the use of intraoperative audio recording feels excessive. Many fear the privacy infringement of the surgical team that follows and in particular the negative impact it might incur on operating room atmosphere. Moreover, nowadays only endoscopic surgeries are suitable for easy recording; everything is set up and implementation could roll out promptly with respect to the technical aspects. A great challenge remains in recording predominantly open surgeries and dynamic procedures covering large parts of the body and different angles, such as vascular surgery and orthopedic surgery. Unless thoroughly prepped, surgeons are not able to document these kind of procedures on video in an effortless manner whilst adequately covering the majority of the surgery.

Aside from the importance of support among those who are using, or are subject to intraoperative multimedia recording, technological feasibility is just as crucial. The studies reported in **Chapter 6, 7, 10 and 11** have proven that both intraoperative video and audio recording are indeed feasible. Moreover, video recordings provide a significant enhancement to the traditional narrative operative report in terms of depiction of surgical events, an improvement of 25.8 to 32.9 percentage points compared to the traditional operative report alone. Also the use of intraoperative audio recording is able to reduce the number of discrepancies (essential surgical steps that were adequately observed on video but inadequately reported in the operative note), providing a reduction from 23.3% discrepancies to 11.8% with use of audio. In its current form however, being either a full-length recording of the entire procedure, or multiple recorded fragments of key steps, intraoperative video and audio

documentation presents difficulties in both recording and reviewing, as the former is error prone and the latter is notably time consuming.

In the topic of cholecystectomy it is general knowledge that results have improved over time. Due to the beneficial effects of the minimally invasive approach, most surgeons jumped to the opportunity to exchange the traditional 'open' approach for a laparoscopic one. This resulted in a tremendous increase of laparoscopic cholecystectomies in only a few years time.[23-25] This however was accompanied with an upsurge of bile duct injury, with rates up to 1.5% compared to an average of 0.2% in open cholecystectomy.[26-34] Only in recent years were surgeons able to reduce this incidence to one comparable to the period before introduction of laparoscopic cholecystectomy, however as mentioned before very variable. With these low incidence rates bile duct injury could be interpreted as a "rare occurrence". However, note has to be taken that cholecystectomy, with a number of up to 200 procedures performed per 100,000 inhabitants annually in Europe and the United States, is the most frequently performed type of abdominal surgery today.[35,36] This high volume, associated with the impact that bile duct injury inflicts on patient morbidity and mortality, accumulates to a very common yet severe complication.

Articles covering cholecystectomy and bile duct injury have been published in abundance. Despite this, as the systematic review in **Chapter 8** also demonstrates, the level of evidence provided by this body of research is regrettably very modest. A mere 4.4% (4 out of 90) of included articles in this review has a level of evidence of 2 (according to the Oxford Centre of Evidence-Based Medicine[37]) The majority of articles included, 72.2% (65 out of 90) has a level of evidence of 4, i.e. just above expert opinion. This distribution is mainly attributed to the statistical fact that proper research on bile duct injury prevention is quite impractical. In the case of a randomized controlled trial, over 4,500 cases of laparoscopic cholecystectomy should be included *per arm* to adequately address the issue.[38]

Despite the problem of evidence quality in current literature, the lowest incidence of bile duct injury was reported whilst using the Critical View of Safety technique, first offered by Strasberg et al.[39] Having endured much scepsis, many currently recognize the value of this technique. Among others, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the Association of Surgeons of the Netherlands have recommended its use for laparoscopic cholecystectomy.[40,41] Furthermore, in 2018 the Tokyo guidelines committee reached consensus to use the Critical View of Safety whenever possible.[42] Despite this, the correct understanding of critical view of safety technique is presumably considerably less in practice, as we have observed in **Chapter 9**. Most often the Critical View of Safety technique is confused with the infundibular technique, a technique which was standard practice and commendable in open cholecystectomy, and today in the era of laparoscopic cholecystectomy potentially calamitous. An explanation might be the fact that surgeons trained *before* 1995, when the article by Strasberg et al. was published, do not know better or, more regrettably, are reluctant to alter their technique. This hypothesis is supported by the

fact that, in our survey, surgeons with more than 15 years of working experience performed and selected steps appertaining to the Critical View of Safety technique less often than other surgeons. Reasons for not properly understanding the Critical View of Safety technique or using a different approach by some surgeons might the paucity of evidence to validate its use with evidence based medicine. Another reason might be the fact that with a relatively low incidence rate, one surgeon might perform over a hundred cholecystectomies without a single bile duct injury and might therefore consider his technique safe.

It is important to note that obtaining the Critical View of Safety should not be an objective on itself. Sometimes patient factors such as anatomy, inflammation, fibrosis or the presence of adhesions could and should prohibit the use of the Critical View of Safety technique and a different approach should be selected, for instance fundus first dissection, subtotal cholecystectomy or conversion to open cholecystectomy.

Intraoperative cholangiography has also been mentioned as a tool in bile duct injury prevention. This technique however is mostly frequented by US and UK surgeons, and rarely used by European and Asian surgeons[43-46]. Most importantly, in regions where this technique is utilized, its use was most likely dependent on surgeon's or institution's preference, rather than patient characteristics and scientific evidence, as should be desired. Also, due to an ongoing decrease in use, many surgeons in training lose the opportunity to familiarize themselves with this technique.[47] If this trend continues, it is imaginable that in the near future, intraoperative cholangiography becomes obsolete for 'straightforward' laparoscopic cholecystectomy and only practiced in specialized centers for hepatobiliary surgery.

FUTURE PERSPECTIVES

Legislation and ethics

Before intraoperative video and/or sound recording could be implemented in any capacity, fundamental ethical and legal concerns should be addressed. Legislation specifically tailored to these methods are to be formulated, considering that next to no other situation exist in which privacy of both patients and medical practitioners are exposed in such a manner and therefore in need of protection. Also, instead of measuring everything with the same standards, the medical community in cooperation with government authorities should clearly and decisively state criteria for different types of documentation what makes it identifiable. For instance in radiology, the majority of plain film radiographs without patient identifiers are near impossible to trace back to the patient. For head and facial CT-scans however, it is possible to reconstruct the skin surface to a 3D model of the face, as the data to achieve this is essentially included in the image processor.[48] In this case, accuracy for recognition compared to facial color photographs is reported to be 61%.[49] The situation with intraoperative recording of information, albeit the form of text, image, audio or video, is quite similar,

as various methods of documentation pose different risks of privacy exposure. To state that all or none of these are a privacy infringement is detrimental and short-sighted. Furthermore, the multiple streams of information that are in play serve multiple purposes; among others information regarding the surgical procedure that could be implemented in the patient record and information that could be used for quality assurance. Data gathered for each of these purposes have different requirements in terms of accessibility, storage and ownership. To simply amass all information under one label would be a serious disservice for the other.

Technological aspects

Currently, most operating rooms are equipped with some sort of recording technology. The quality and ease of use are however highly variable across the board. Newly built or renovated operating rooms often incorporate modern technology, including recording facilities and logistics for live surgery broadcasting. These facilities are essential for implementation of systematic video recording to reach its potential.

In the future we might also see an increased use of artificial intelligence to aid us in these matters. For example, using synoptic operative reports and relating these with intraoperatively recorded video using artificial intelligence might facilitate easy lookup of video segments linked to parts of the report. Also, including data entered in the nursing station, like data regarding opened surgical equipment or registered devices or prostheses used for implant, could provide us with useful information to aid in effortless review of a surgical procedure.

Support by key players

In concordance with the Technology acceptance model (figure 1), two main factors apply for users to accept a new technology.[50] The first is the Perceived usefulness, which is "the degree to which a person believes that using a particular system would enhance his or her job performance".[51] According to the results of our survey in **Chapter 4** this is dichotomous among responding surgical professionals. We have demonstrated in this thesis that intraoperative video and audio recording are in fact useful. However, the fact remains that for an increase in perceived usefulness among key players more research is necessary to ascertain the benefit of intraoperative recording for multiple uses. Additionally, the beneficial results that are expected to arise from this research should then be gathered and consolidated in a concrete recommendation for potential users, for instance in the creation of a professional guideline.

The second factor is the perceived ease-of-use, which is "the degree to which a person believes that using a particular system would be free from effort". For now, only feasibility and potential benefit has been demonstrated. Currently, and due to the differences in infrastructure in different hospitals, easy-of-use is varying widely. If usefulness is present without doubt, ease-of-use should be next in line. Because when recording certain aspects of surgery are complicated to perform, positive attitude towards the technology is hard to find.

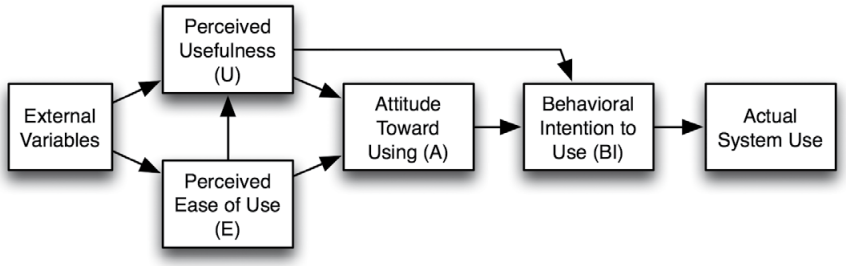

Figure 1. Technology acceptance model (Davis, Bagozzi & Warshaw 1989)

Furthermore, mere intraoperative recording to eventually be used as an afterthought is obviously insufficient. To err is human and therefore iatrogenic complications will happen in surgery. The main benefit in the situation of intraoperative recording is that, unlike now, most complications can be condensed to the its exact origin. However, this necessitates routine and systematic review by the involved parties at the least.

But why stop there? A successful surgery is not a result of the surgical aspect alone. Conversely, the surgical facets are not solely to blame when surgery has gone awry. Surgery is a team effort, only successful when all team players are working in coalition. Today, each of these team members have their own, unique stream of information, often segregated from one another. If one is to adequately review a complicated procedure, one should not only focus on just one of these information streams. 'The surgical black box', which is currently receiving critical acclaim, is the first project to make an attempt at combining these information streams between team members. It should be a priority in any case to approach each procedure in the operating room as a proper team endeavour and consequently team training must be focused on this.

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