



# Safety and effectiveness of live broadcast of surgical procedures: systematic review

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## Abstract

**Introduction** Live Broadcast of Surgical Procedures (LBSP) has gained popularity in conferences and educational meetings in the past few decades. This is due to rapid advancement in both Minimally Invasive Surgery (MIS) that enable transmission of the entire operative field and transmission ease and technology to help broadcast the operation to a live audience. The aim of this study was to update the evidence with specific emphasis on the patient safety issues related to LBSP in MIS.

**Methods** A systematic review of the literature was performed using Medline, Embase and Pubmed using defined search terms related to LBSP in educational events across all surgical specialities, in accordance with the PRISMA guidelines. We also consolidated the prior guidelines and position statements on this topic. Outcomes included reports on the educational value of LBSP as well as patient safety outcomes and ethical issues that were captured by clinical outcomes.

**Results** A total 1230 abstracts were identified with 27 papers meeting the inclusion criteria (13 original articles and 14 position statements/guidelines). All studies highlighted the educational benefits of LBSP but without clear measure of these benefits. Clinical outcomes were not compromised in 9 studies but were inferior in the remaining 4, including lower completion rate of endoscopic surgery and higher rate of re-operation. Only nine studies complied with dedicated consent forms for LBSP with no consistent approach of reporting on maintaining patient confidentiality during LBSP.

There was a lack of recommendation on standardised approach of reporting on LBSP including the outcomes across the 14 published guidelines and positions statements.

**Conclusions** Live Broadcast of Surgical Procedures can be of educational value but patient safety may be compromised. A standardised framework of reporting on LBSP and its outcomes is required from an ethical and patient safety perspective.

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**Keywords** Live · Surgery · Broadcast · Safety

## Background

Live broadcast of surgical procedures (LBSP) has gained popularity in the past few decades and is commonly used in educational events such as conferences and live digital learning events. It is regarded as an opportunity for experts to demonstrate novel techniques and emerging technology especially in complex procedures for the benefit of a targeted audience [1].

This has been particularly applied to the field of Minimally Invasive Surgery (MIS) such as robotic, laparoscopic and or endoscopic techniques as the operative field can be live streamed to a large audience. It can also be an opportunity to see how an experienced surgeon would deal with intraoperative complications, including the decision making process of how they respond to unexpected findings/events.

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This has been commonly used within the context of educational conferences and events where narration provided allows the audience to engage and interact with the experts through the moderator(s).

There have been, however, some patient safety and ethical concerns during these live surgery broadcast [2]. Surgeons will often travel to perform LBSP outside their normal institutions, which may result in ‘jet lag’ and added fatigue that can alter their performance. Importantly, these surgeries are often complex techniques and or emerging technology which can be technically demanding, adding more stress on the surgical team. Additionally, surgeons often work with potentially unfamiliar teams and equipment which may add further anxiety to the performing surgeon, who may already feel under more pressure to perform in front of a large audience.

Furthermore, the extra personnel required to conduct the live transmission may contribute to distraction to the operating team and may affect the level of infection control in the theatre environment. Finally, expert surgeons do not routinely follow-up those patients and so will be reliant on the host team to care for them postoperatively. Given the likelihood complexity of those cases, host teams may be not familiar with the associated risks and complications.

An evidence synthesis was performed in 2014 looking at the educational value and patient safety of LBSP [3]. They found a comparable rate of complications between procedures performed as LBSP compared to non-LBSP. However, the success rate in some procedures was lower in LBSP group, as demonstrated in endoscopic completion rate. Since the last review, there has been a rapid uptake of MIS across all specialities with more reports on the application LBSP in surgical training. This, however, has been significantly impacted by the unprecedented COVID-19 pandemic with the cancellation of national and international meetings [4]. Alternative ways of remote teaching such as webinars have been widely adopted during the pandemic, but it is unclear if LBSP should be an integral part of this virtual teaching. Therefore, it was necessarily to update the evidence synthesis and re- appraise the literature.

The focus of this review is patient safety issues related to LBSP in Minimally Invasive Surgery (MIS), but a more global view on the matter is also addressed such as ethics and confidentiality.

## Methods

### Search strategy

A comprehensive review of the literature was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [5]. The PubMed, Embase and Medline electronic databases

were used and a search of the data from 1 March 2005 till 20 February 2021 was performed. The start date was chosen to reflect some of the earliest substantial reports on LBSP in the literature (excluding case reports). Search terms used combinations of “broadcast”, “live surgery”, “safety”, “ethic” and “live surgical broadcast” separated by the Boolean operator “AND”, were used. The search was performed independently by two separate authors. A further search was performed on 10 October 2020 with search terms “COVID-19”, “live surgery”, “live surgical broadcast”, in order to capture any reported literature during the pandemic to date. A subsequent manual search of the related study references was conducted in order to capture reports that were missed in the initial search, and all identified suitable studies were included. Abstracts and conference entries were excluded at initial screening due to the inability of capturing complete sets of data.

### Study selection

Studies were eligible for inclusion if they were written in the English language and available in full text. More specifically the following inclusion criteria were used: randomised controlled studies, controlled trials or cohort studies reporting the outcomes of LBSP among all surgical specialties; studies that reported broadcast in conferences as well as other educational events and the guidelines on LBSP across the different surgical bodies and institutions were also included.

There was no restriction on the type of MIS that was conducted and a wide range of procedures were included.

Studies were excluded if the total number of cases used was less than ten. All duplicate studies or studies using the same data set were excluded. All studies using paediatric patients were not included. Only studies reporting outcomes of procedures and complications were included, studies just reporting on delivery of LBSP or ethics were excluded. Finally, reports on social media transmission that were not broadcast live were also excluded.

### Outcome measures

The number of patients, demographics (age and sex), type of surgery and reported outcomes and complications were recorded. This included success of procedure (there was heterogeneity in the reporting of this outcome dependant on the surgery performed), return to theatre and readmissions. Complications reported were compared to those patients who were not involved in LBSP.

Additionally, data on ethics, were also captured including dedicated consent forms for LBSP, maintain confidentiality through the live surgery broadcast and reporting on outcomes of those procedures.

## Data extraction and analysis

Data extraction was performed independently by two separate authors (MA and MC). After the initial screening of titles and abstracts, articles which fulfilled the eligibility criteria were identified and full text accessed for further analysis.

The methodological quality of the studies was assessed using the Risk of Bias in Non-randomised Studies of Interventions tool (ROBINS-1).

The results are described using a narrative analysis, and primarily grouped by the outcome assessed. Meta-analysis could not be performed on the data due to the heterogeneity of the studies as most of the studies were not statistically comparable.

## Results

### Demographics

The search strategy identified 1230 abstracts. After removal of duplicates and exclusions were made, 27 final manuscripts were selected for data extraction, including thirteen original papers and fourteen guidelines/position statements. The PRISMA diagram is summarised in Fig. 1.

Eight papers reported on events performed at a single centre while five were multicentre studies in the analysed 13 full text papers [6–18]. Eight papers reported on events live streamed from a European country, with the remainder being from the USA and Asia. Only two of the papers reported on the number of attendees at their event [8, 18] (Table 1).

Eight papers were retrospective unadjusted cohort studies [8–11, 15–18], four retrospective case matched [6, 12–14] and one prospective case matched [7]. They addressed a wide range of specialities including urology, endoscopy, upper gastrointestinal surgery and cardiac interventions.

### Patient safety outcomes

Of the 13 papers included, nine reported no difference in the complications nor the rate of success of the procedures performed (Table 1).

Four papers reported inferior outcomes in live broadcast. Ramirez-Backhaus et al. looked into the outcomes of LBSP in laparoscopic radical prostatectomy [7]. 23 patients were broadcasted live compared to 46 matched controls. They found no difference in the rate of perioperative or postoperative complications. However, they reported a significant

difference in the rate of positive surgical margins in the LBSP group (43.5% vs 17.4%).

Ruiz de Gordejuela et al. analysed data obtained from bariatric courses, where LBSP was performed over a ten-year period [8]. Procedures performed included Laparoscopic Roux-en-Y gastric bypass, sleeve gastrectomy as well as endoscopic procedures. These were compared to patients undergoing similar procedures, not broadcast live. However, they were not matched controls. They found higher complication rates in LBSP and higher rate of re-operation needed. In the LBSP group, 13% of patients experienced complications as follows: Clavien type I (4 cases), Clavien type II (3 cases) and Clavien type III (6 cases) with bleeding being the most common complication (72.4%). This is compared to 6.7% in the group not performed as LBSP.

The two other studies reported inferior outcomes related to completion of the procedures during Endoscopic Retrograde Cholangio pancreatography (ERCP). Liao et al. investigated ERCPs broadcast live and compared them to matched controls across 36 conferences [13]. There was no statistically significant difference in the rate of complications between patients in LBSP and control (10.3% vs. 8.6%). However, there was a lower success rate in the live broadcast group (94.1% vs. 97.5%). Ridditid et al. similarly searched the difference in outcomes and success rate in 82 risk-stratified ERCPs performed during live broadcast compared to matched controls [14]. The complexity of the ERCP was divided as per the grading proposed by Cotton et al. [19]. Patients who had level 1 and 2 procedures were classified as the standard group and patients who had level 3 and 4 procedures were classified as the complex group. They found that in technically simpler procedures there was no significant difference in the complications or success rate between LBSP and matched controls. However, the success rate was significantly lower in those procedures performed live compared to controls (73% vs. 90%; OR, 0.3; 95% CI 0.14–0.69) in more complex ERCPs. The overall success rate in the LBSP group was lower than controls (81% vs. 91%; OR, 0.4; 95% CI 0.21–0.85), but the complication rates were overall similar (6% vs. 3%; OR, 2.2; 95% CI 0.68–7.19).

Legemate et al. reported on the use of LBSP in ureterorenoscopic (URS) and percutaneous nephrolithotomy (PNL) urinary stone procedures and compared them to patients not performed as LBSP (unmatched). No statistically significant difference in the complication rate was found when compared to routine surgical practice. However, they found that the anaesthetic time was significantly longer in the LBSP group undergoing ureterorenoscopic procedures. They also found the retreatment rate was higher in this group. Subsequent multiple logistic regression analyses revealed that there is no association between LBSP and inferior outcomes (after adjusting for confounding variables)

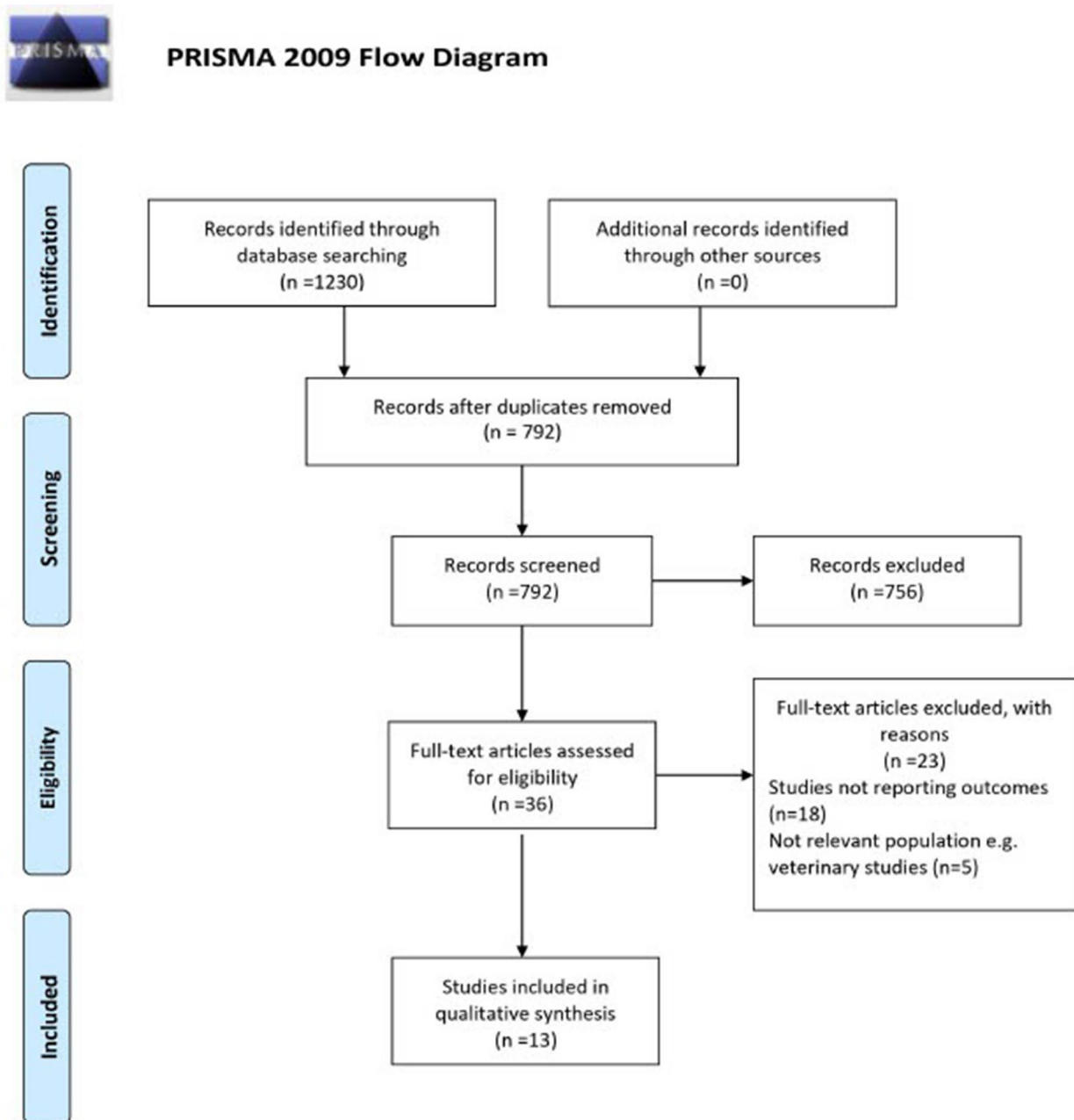


Fig. 1 PRISMA Diagram

and so the authors concluded that LBSP does not compromise patient safety [17].

### Ethics, confidentiality and consenting

Dedicated consent forms were reported to be used in only 9 studies [6–11, 14–16]. One study reported on a pooled sample of data across several events and there heterogeneity in reporting dedicated consent [18]. In those that included a

dedicated consent process, there was a lack of clarity of the contents of the consent form for LBSP.

Four of the 13 studies did not expand how they maintained ethics and confidentiality [7, 12, 15, 17] during the live surgery broadcast and 5 papers only mentioned that either their study was approved by the local ethics committee or they adhere to their associated guidelines, without further clarification.

**Table 1** Summary of included studies [6–18]

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demogra- phy	Audience	Num- ber of L BSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Ogaya- Piniés et al	European Urology Focus	Retrospec- tive case matched	2019	Single centre	USA	Safety of Live Robotic Surgery: Results from a Single Institu- tion	Dedicated	Adhered to the EAU code of conduct for L BSP, patient anonymity and confi- dentiality maintained at all time, no sponsoring allowed and patient advocate present at all times	Presented at local, national and inter- national congress, single centre, per- formed by single surgeon, did not mention numbers presented to, pro- cedures per- formed in home institu- tion	Inter- national	36	Robotic- assisted radical pros- tatectomy	Robotic (n = 36)	<b>Intraoperative</b> (operative time, EBL, lym- phadenectomy) <b>Postoperative</b> (LOS, compli- cations, time to potency/ continence) <b>Pathological</b> (positive surgi- cal margins)	No differ- ence	No differ- ence
Ramirez- Baehaus et al	Urology	Prospective case con- trolled	2019	Single centre	Spain	Live Sur- gery for Laparo- scopic Radical Prosta- tectomy- Does it Worsen the Out- comes? A Single- centre Experi- ence	Dedicated	Not stated	Presented locally live in audit- rium in courses. Surgeries per- formed by 3 different surgeons	National	23	Laparoscopic prostatec- tomy	Laparoscopic (n = 23)	<b>Intraoperative</b> (operative time, EBL, intraoperative complications) <b>Pathological</b> (Positive surgi- cal margins, biochemical recurrence) <b>Postoperative</b> (complications, re-operations)	Higher positive surgical margin in L BSP	No differ- ence

Table 1 (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demography	Audience	Number of LBSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Gordel-juela et al	Surgery for obesity and related diseases	Retrospective unadjusted cohort	2017	Single centre	Spain	Live surgery courses: retrospective safety analysis after 11 editions	Dedicated	Patient anonymity maintained at all times, no personal data reported to the audience, approved by local ethics board	Presented at international bariatric course, each edition approximately 100 surgeons in attendance. Local and international surgeons. Broadcast at institution auditorium	International	107	obesity surgery	Laparoscopic (n=98) Endoscopic (n=10)	<b>Morbidity Re-operations Presentations to the emergency department</b>	Lower success in LBSP	Higher is LBSP
Mullins et al	Urology	Retrospective unadjusted cohort	2012	Multi-centre	USA	Live robotic surgery: Are outcomes compromised?	Dedicated	Patient identity was protected at all times in accordance with Health Insurance Portability and Accountability Act regulations. No breach in confidentiality occurred during these cases	Cases performed by 5 different surgeons at home and distant institutions, multi-institutional, broadcast via teleconference	National	39	Robotic-assisted partial nephrectomy	Robotic (n=39)	<b>EBL Operating time LOS Surgical margins Perioperative complications</b>	No difference	No difference

**Table 1** (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demography	Audience	Number of LBSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Itam et al	Female pelvic medicine and reconstructionsurgery	Retrospective unadjusted cohort	2020	single centre	UK	Female Urology and Uroynaecology: The Outcome of Patients Participating in Live Surgical Broadcasts	Dedicated	Followed code of conduct adapted from the EAU publication	Presented in annual Female Urology and Uroynaecology Master class. All surgery performed by same six consultants (4 urology and 2 uroynaecology)	National	53	Uroynaecology	SUI surgery POP repair VVF closure UD excision Surgery for mesh complications/urethroplasty 2nd-Stage SNM Formation of Mitrofanoff channel Botulinum toxin A injections/ FSTL insertion	30- and 90-day complications. Surgical success(defined in the paper)	No difference	No difference
Eliyahu et al	JACC: Cardiovascular Interventions	Retrospective unadjusted cohort	2012	Single centre	Israel	Patient safety and outcomes from live case demonstrations of interventional cardiology procedures	Dedicated	Only mention is that the study was done with compliance with the local human studies committee	Conferences were national and international, majority of operators were from the home institution with few cases from overseas	International	103	IR procedures (cardiac=66; carotid=15; peripheral=1; valvular=2; congenital=12; ablation=7)	Percutaneous interventional (n = 103)	<b>In hospital</b> (myocardial infarction, stroke, death, unsuccessful procedures, minor complications) <b>Discharge to 30 days</b> (myocardial infarction, stroke, death, repeat intervention)	No difference	No difference

Table 1 (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demogra- phy	Audience	Num- ber of LBSF	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Schmit et al	Endo- copy	Retrospec- tive case matched	2005	Single centre	Belgium	Complica- tions of endo- scopic retro- grade cholangio- pancrea- tography during live endos- copy workshop demon- strations	None stated	Not described, but men- tion that true emer- gencies such as cholangitis were not delayed	Presented in annual endos- copy work- shops in Erasmus Univer- sity Hos- pital in Brussels. Mix- ture of foreign and local experts. Numbers presented to not men- tioned	National	168	ERCP	Endoscopic (n = 168)	<b>Delay to ERCP</b> (in order to transmit) <b>Dura- tion of ERCP</b> <b>Complications</b> <b>Success of procedure</b> ( complete, par- tial or complete failure) <b>Repeat procedure</b>	No differ- ence	No differ- ence
Liao et al	Am J Gastro- entrol- ogy	Retrospec- tive case matched	2009	Multi- centre	China	How safe and suc- cessful are live demon- strations of therapeutic ERCP? A large multicen- tre study	No indica- tion if dedi- cated, just stated 'written informed consent was obtained'	Study was approved by the Ethics Committee of local insti- tutions	Presented at 36 endos- copy confer- ences across 14 centres in China. Pre- sented by a mixture of local, domestic, visiting and local experts. Numbers attend- ing not stated	Interna- tional	406	ERCP	Endoscopic (n = 406)	<b>Success</b> (Com- plete, partial, complete failure) <b>Compli- cations</b>	Lower suc- cess in LBSF	No differ- ence



**Table 1** (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demogra- phy	Audience	Num- ber of LBSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Riditid et al	Surg endos- copy	Retrospec- tive case matched	2012	Single centre	Thailand	Outcome of endos- copic retrograde cholan- giopan- creatog- raphy during live endos- copy demonstra- tions	Dedicated	Conference program was approved by the King Chula- longkorn University Medical Institu- tional Review Board and TAGE	Annual LD work- shop in Thailand by the King Chula- longkorn Memo- rial hospital in col- labora- tion with Thai Associa- tion for Gastro- intestinal Endos- copy. LBSP per- formed by overseas experts only, no met- tion of numbers attend- ing	Interma- tional	82	ERCP	Endoscopic (n = 82)	<b>Success</b> (Com- plete, partial, complete fail- ure) <b>Complica- tions</b> <b>Duration of procedure</b> <b>LOS</b>	Lower suc- cess in LBSP	No differ- ence

Table 1 (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demography	Audience	Number of LBSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Franke et al	JACC: Cardiovascular Interventions	Retrospective unadjusted cohort	2009	Multi-centre	Germany/ Italy	Complications of carotid stenosis during live transmissions	Dedicated	Not stated	22 international conferences from 3 high volume centres, 2 in Germany and 1 in Italy. Guest performed the LBSP. No mention on numbers attending	International	186	Carotid stenting	Percutaneous interventional (n = 186)	Technical success, complications, rate of myocardial infarction, mortality	No difference	No difference
Seeburger et al	European Journal of cardiothoracic surgery	Retrospective unadjusted cohort	2011	multi-centre	Germany/ Belgium	Live broadcasting in cardiac surgery does not increase the operative risk	Patients were consented for surgical procedure and mission for live broadcasting to the respective meeting audience and recording of the procedure the day before surgery	Adhered to the conduct of live surgery developed by the EACTS Techno College Committee, but no specific mention of confidentiality	Performed in 4 clinical sites across Germany and Belgium and broadcast across 32 scientific meetings across Germany and Belgium to international audience. Mixture of local and guest operators. Numbers not mentioned	International	250	Cardiac surgery	Mitral valve 126 Aortic valve 34 CABG 29 Aortic 15 Atrial fibrillation 13 Heart failure 7 Congenital 26	Mortality, complications, re-operation	No difference	No difference

**Table 1** (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demography	Audience	Number of LBS	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Legemate et al	World Journal of Urol- ogy	Retrospec- tive unad- justed cohort	2017	Single centre	Nether- lands	Outcome from 5-year live surgical dem- onstra- tions in urinary stone treat- ment: are outcomes compro- mised?	No indica- tion if dedicated	Not men- tioned, only generic recom- menda- tions on ethics are included in the discus- sion but no description on what was imple- mented in the study	Streamed from academic centre in the Neth- erlands, mixture of host and guest surgeons. Interna- tional setting. Deliv- ered as part of 2 day course, no informa- tion on number of par- ticipants	Interna- tional	151	Ureteroreno- scopic (URS) and percutaneous nephrolitho- my (PNL) urinary stone procedures	URS =95, Percutane- ous =56	Intraoperative complications Postoperative complications, operation time, length of hospital stay, stone-free rate and retreatment rate	No signifi- cant dif- ference in rate of intraop- erative and post- operative compli- cation rate. No differ- ence in the com- plication grade score. How- ever, opera- tion time signifi- cantly higher in LSD- URS group, retreat- ment rate higher in LSD- URS group. Multiple logistical regres- sion showed no increase in risk in LBS in LBS group	No statis- tically sig- nificant differ- ence

Table 1 (continued)

Authors	Journal	Study type	Year	single/ multi	Country	Name of the article	Consent	Ethics	Demogra- phy	Audience	Num- ber of LBSP	Procedures	Surgical Approach	Outcome measure	Clinical Outcome	Complica- tions
Rocco et al	World Journal of Urol- ogy	Retrospec- tive unad- justed cohort	2018	Multi- centre	Europe	Live surgery: highly educa- tional or harmful	Not met- tioned for the pooled studies, at end stated not needed and says from 2014 adhered to EAU guide- lines	From 2014, all the live surgeries have been organised according to the ethical rules as published by the EAU	Annual attend- ance approxi- mately 538 surgeons, Data from the Congress Chal- lenge in Laparos- copy and Robotics (CILR). Internat- ional audience. Multi- surgeon and multi- institu- tion	Internat- ional	224	<b>Laparoscopic:</b> Radical pros- tatectomy, Partial nephrectomy, Nephrectomy, Cystectomy, Retrop- eritoneal lymphad- enectomy, Sacral colpopexy, pyeloplasty, bladder diverticul- ectomy repair. <b>Robotic:</b> Radical pros- tatectomy, Partial nephrectomy, Cystectomy, Pyeloplasty, Ureteral reim- plantation, ureter- olysis, sacral colpopexy, kidney transplant, fistula repair	Laparo- scopic = 164, Robotic 60	Mortality and complications. Postoperative Morbidity Index	LBSP safe with accept- able out- comes over the 12-year time frame	Low compli- cation rate in LBSP

## Analysis of LBSP guidelines

14 guidelines were identified spanning across different surgical associations, representing four cardiothoracic, one urology, five endoscopy and one from ophthalmology. The remaining three were published by Royal Colleges of Surgeons of England and Australia and The Royal Australian and New Zealand College of Ophthalmologists [1, 20–32].

All guidelines and position statements addressed the issue of patient safety (Table 2). The majority are in agreement that a moderator must be present in order to facilitate the interaction between the operator and the audience. This is in order to allow the operator to fully focus on the procedure and avoid distraction. There is unanimous agreement that if it is felt that continued broadcasting will have an adverse effect on the patient, it should be immediately terminated. There was, however, no proposed framework on a reporting mechanism of patient outcomes during and following LBSP except by the European Association of Urology [1].

All guidelines encouraged familiarity with the location and equipment. Therefore, some recommend that where possible the surgeon should perform the procedure from their ‘home’ institution. Where this is not possible, they should familiarise themselves with the environment beforehand and should be working with a team highly familiar with the workplace. They should submit preferences for equipment beforehand in order to avoid unfamiliarity during the procedure. Personnel in theatre should be kept to a minimum and non-clinical staff must not interfere with the procedure.

There is also unanimous agreement among all the published guidelines for the need to have a dedicated consent process for LBSP. The consent should include discussion about the risks of LBSP to the patient such as increased surgeon distraction and the possible breaches of confidentiality. Also the consent should declare that there are potentially limited benefits to the patient to participate in LBSP. In a proportion of guidelines, there is a necessity for the operating surgeon or physician to meet and be involved in the consenting process with the patient in person before the procedure.

All guidelines stated that all attempts need to be made to protect patient confidentiality during and after the procedure. This involves the protection of patient identifiable information appearing on monitors and screens inadvertently.

The patient needs to at all times be reassured that they may refuse or withdraw their consent at any point without their care being affected. If their procedure is delayed due to withdrawal of consent, all attempts must be made to rearrange their procedure in a timely manner. There must be no coercion of the patient.

## Quality assessment

Using the ROBINS-I tool, eight of the studies had an overall moderate risk of bias and five studies had a serious risk of bias (Fig. 2).

## Educational value

There was a paucity of original objective data reporting the educational value among the papers.

In their synthesis, Brunckhorst et al. addressed the educational value of LBSP. They note the lack of objective data on the subject. The majority of data reported is through subjective surveys showing participants rating LBSP highly as an educational tool. Only one study reported by Brunckhorst et al. addressed the validity of LBSP objectively. McIntyre et al. compared students in operating theatres against students watching LBSP. In the LBSP group, students asked four times as many questions compared to the group in the operating theatre and had fewer questions unanswered [3].

From the included studies in this synthesis, none measured objectively the educational value.

## Discussion

Live surgical broadcast is now widely used among the different surgical specialities due to the perceived educational value of these events. Patient safety concerns however have been raised over the outcomes of patients during LBSP, owing to the different circumstances in which their surgery is being performed. Given the global impact of the pandemic on educational events, the role of live surgery broadcast within the context of virtual training curricula became more unclear. We felt it was appropriate to re-visit this topic, update the literature on LBSP and summarise the outcomes and the wider issue of ethics and patient safety in relation to MIS.

## Educational value

Although the literature in this review highlighted the potential educational value of LBSP, it was difficult to draw a conclusion on the magnitude of benefits as this often was not objectively measured and was subjectively reported via surveys. Attempts have been made to do this via questionnaires after events by Skouras et al. [33], which was not included in the analysis as they did not report on clinical outcomes. They conducted surveys to examine the educational value of plastics and ENT live and or pre-recorded

**Table 2** Summary of the guidelines [1, 20–32]

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
Royal College of Surgeons Position Statement	Royal College of Surgeons of England	2017	Guideline	<ul style="list-style-type: none"> <li>• Dedicated consent for the LBSP</li> <li>• Patient needs to have capacity</li> <li>• Emphasise no advantage or disadvantage of participating</li> </ul>	<ul style="list-style-type: none"> <li>• Unnecessary personnel and equipment should be avoided in the operating room(OR)</li> <li>• The recording of the video should not interfere with the procedure</li> <li>• LBSP should be immediately terminated if there is an adverse effect on procedure</li> <li>• If there is interaction with the audience a moderator should be present</li> <li>• If the surgeon is not present to care for the patient post-operatively then a delegated member of the host team needs to be identified</li> </ul>	<ul style="list-style-type: none"> <li>• Patient's personal information needs to be handled with great care to avoid breaching confidentiality</li> <li>• LBSP should not breach the relationship of trust between, surgeon, patient and operating team</li> </ul>
Broadcast of Surgical Procedures as a Teaching Instrument in Cardiothoracic Surgery	American Association for Thoracic Surgery	2008	Joint opinion between the American Association for Thoracic Surgery (AATS) and The Society of Thoracic Surgeons (STS)	<ul style="list-style-type: none"> <li>• LBSP consent must be obtained by the operating surgeon himself</li> <li>• The patient must be informed of potential increased risk of harm as well as audience number and educational value</li> </ul>	<ul style="list-style-type: none"> <li>• LBSP is less acceptable with greater scheduling constraints, greater complexity of procedure, greater interaction with audience, less familiarity of the OR environment</li> <li>• The surgeon should be very familiar with the procedure and the medical equipment</li> <li>• Where ever possible the surgery should be broadcast from the surgeon's home theatre</li> <li>• Preferably the surgeon's own team should participate, or at least members highly fluent in the same language</li> <li>• Video crew should not interfere with the operation</li> <li>• Discussions should be one way from surgeon to audience. If a great need for two way exists this should be done through a moderator</li> </ul>	<ul style="list-style-type: none"> <li>• The attending surgeon should take all steps to protect the patient's personal privacy and confidentiality of all medical information</li> </ul>

Table 2 (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
Guidelines to Live Presentation of Thoracic and Cardiovascular Surgery	The Japanese society for Cardiovascular surgery	2007	Guideline	<ul style="list-style-type: none"> <li>• Dedicated consent by the surgeon should be obtained directly with the patient and the patient should be informed that there may be added risk</li> <li>• The consent must be signed on paper</li> <li>• Consent also needs to be obtained from the ethics committee where the procedure will take place</li> </ul>	<ul style="list-style-type: none"> <li>• The surgeon must not allow any interference with the surgery in the quest for superior imaging</li> <li>• Complex procedures should be avoided</li> <li>• The surgeon should be ideally performing the surgery in his home institution; if this is not possible preparations must be in place to adjust the environment</li> </ul>	<ul style="list-style-type: none"> <li>• Personal information must be carefully managed. When displaying procedures, great care needs to be taken to ensure that no personal information is visible</li> </ul>
EAU Policy on Live Surgery Events	European Association of Urology	2014	Systematic review and internet/panel-based consensus	<ul style="list-style-type: none"> <li>• A specific Informed Consent to Live Surgery addendum</li> <li>• Must be completed, signed by the local and guest Surgeons, and retained in the patient's medical records</li> <li>• The patient has right to withdraw consent at any time</li> <li>• The patient must meet the operating surgeon the day before surgery to consent</li> </ul>	<ul style="list-style-type: none"> <li>• The operating surgeon must submit in advance preference for equipment</li> <li>• Anaesthetists must be involved in the planning process. Assistants should be suitably registered and experienced</li> <li>• All unnecessary equipment or personnel should not be in theatre</li> <li>• Representatives from industry should only be present if their presence is mandatory and should be appropriately registered by the host hospital</li> <li>• Delays for live proceedings must be avoided</li> <li>• An experienced urologist must be present to act as patient advocate</li> <li>• Presence of one or more moderators is recommended. Outcomes and complications must be submitted to the EUA Live surgery registry and documented in the revised Martin criteria</li> </ul>	<ul style="list-style-type: none"> <li>• Patient dignity, anonymity and confidentiality to be maintained at all times</li> </ul>

Table 2 (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
SCAI/ACCF/HRS/ESC/SOLACI/APSIC Statement on the Use of Live Case Demonstrations at Cardiology Meetings	American College of Cardiology Foundation, the Heart Rhythm Society, and the Society for Cardiology Interventions	2010	Expert Consensus	<ul style="list-style-type: none"> <li>The patient must be counseled on the procedure by an experienced physician</li> <li>Two separate consent processes are needed for the procedure and LBSP</li> <li>The patient can withdraw consent at any time without penalty</li> </ul>	<ul style="list-style-type: none"> <li>A moderator should be present</li> <li>Serious complications should be dealt with "off camera"</li> <li>Visiting operator should work with an operator highly familiar with the lab and equipment</li> </ul>	<ul style="list-style-type: none"> <li>The patient's identity should not be identified at any time</li> <li>Care needs to be taken to not inadvertently display patient information on monitors</li> </ul>
A guideline for live endoscopy courses: an ASGE white paper	American Society for Gastrointestinal Endoscopy	2001	Guideline	<ul style="list-style-type: none"> <li>An informed consent is required which includes course details and who the operator will be</li> </ul>	<ul style="list-style-type: none"> <li>A host physician needs to be in the OR as well as the main operator</li> <li>Careful placement of audio-visual equipment is needed</li> <li>The operator needs to have familiarity with the facilities and staff</li> <li>Representatives of industry must not interfere with patient care</li> </ul>	<ul style="list-style-type: none"> <li>Careful placement of audio-visual equipment to accommodate this</li> </ul>
Recommendations of the ESGE workshop on ethical legal issues concerning live demonstrations in digestive endoscopy. First European Symposium on Ethics in Gastroenterology and Digestive Endoscopy	ESGE	2003	Expert opinion	<ul style="list-style-type: none"> <li>Consent to be obtained by local organiser detailing the procedure and also consenting for the live broadcast including advantages and disadvantages</li> </ul>	<ul style="list-style-type: none"> <li>The performing physician should be assisted by two moderators, at least one of whom is local</li> <li>The moderator has the final decision for the treatment</li> <li>Only staff involved in the treatment of the patient/audio-visual transmission should be present in the room</li> <li>Industry representatives should be carefully avoided</li> <li>The moderator should act as the interface between the expert and the audience</li> </ul>	<ul style="list-style-type: none"> <li>Acknowledged potential difficulty and the need to maintain confidentiality and privacy of the patient</li> </ul>



**Table 2** (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
Live endoscopy events (LEEs): European Society of Gastrointestinal Endoscopy Position Statement – Update 2014	ESGE	2014	Guidelines	<ul style="list-style-type: none"> <li>• A separate additional consent specific to live endoscopy should be signed</li> <li>• Patient must be informed that they can withdraw their consent at any time or refuse to participate</li> </ul>	<ul style="list-style-type: none"> <li>• Independent patient advocate should be present</li> <li>• A pre-procedure discussion should take place with the staff</li> <li>• The operator should agree all equipment needed in advance</li> <li>• Excessive prolongation must be avoided</li> <li>• There should be two moderators one in the clinical room and one at the conference centre</li> <li>• The moderator must interrupt the procedure if the patient is at risk of harm</li> <li>• Avoid high risk patients</li> <li>• Only personnel involved in the procedure/education should be in the clinical room</li> <li>• Representatives of industry must not interfere with the procedure</li> </ul>	<ul style="list-style-type: none"> <li>• Every attempt must be made to keep all confidential information anonymous</li> </ul>
Live transmission of surgery	Royal Australian College of Surgeons	2016	Position statement	<ul style="list-style-type: none"> <li>• The patient needs to be counselled on the risks of the operation and the specific risks of LBSP</li> </ul>	<ul style="list-style-type: none"> <li>• The operator must be prepared to terminate the procedure if necessary</li> <li>• The operator must be prepared to change the planned procedure if circumstances dictate</li> <li>• The operator should be familiar with the staff and procedure room</li> <li>• The operator should know who the audience will be</li> <li>• There needs to be a moderator to co-ordinate the interaction between the operator and the audience</li> </ul>	<ul style="list-style-type: none"> <li>• Patient confidentiality needs to be maintained at all times</li> </ul>

Table 2 (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
OMED recommendations for the ethical performance of live endoscopy demonstrations	World Endoscopy Organisation	2016	Position statement	<ul style="list-style-type: none"> <li>The expert should be introduced to the patient and have the opportunity to discuss the indication and treatment proposed</li> <li>Informed consent must be obtained and must include the advantages and disadvantages of the live course element</li> </ul>	<ul style="list-style-type: none"> <li>A course director must be identified who has final authority over decisions</li> <li>The operator must be assisted by at least one moderator in the endoscopy room including one from the local staff</li> <li>Interactive discussions should not influence clinical decisions taken</li> <li>The number of personnel in the room should be limited to those involved in performing the procedure, teaching and operating the audio–visual equipment</li> </ul>	<ul style="list-style-type: none"> <li>Patient confidentiality needs to be respected including image acquisition and documentation</li> </ul>
Updated guidelines for live endoscopy demonstrations	American Society for Gastrointestinal Endoscopy	2010	Position statement	<ul style="list-style-type: none"> <li>The consenting process must include involvement in LBSP</li> <li>The patient must be assured that the standard of care will not change based on their involvement</li> </ul>	<ul style="list-style-type: none"> <li>A patient ombudsman (with no conflict of interest) should be present</li> <li>The procedure should be preferentially performed by the patient's treating physician</li> <li>There must be no representatives of industry during the transmission</li> </ul>	<ul style="list-style-type: none"> <li>Patient confidentiality including health records should be at all times maintained</li> </ul>

**Table 2** (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
Live Case Demonstration of Interventional Cardiology Procedures	American College of Cardiology Foundation	2012	Position statement	<ul style="list-style-type: none"> <li>The patient needs to consented on the risks of live transmission, increased risk of infection, prolongation of anaesthesia, increased contrast use, increased radiological exposure, distraction of the operator leading to complications, increased risk of disclosure of patient information</li> <li>A dedicated consent form should be used and patients should be informed that they will have no clinical benefit from participating in live procedure</li> </ul>	<ul style="list-style-type: none"> <li>Procedures should be performed in a 'home' institution where equipment and facilities are familiar</li> <li>A moderator should be present</li> </ul>	<ul style="list-style-type: none"> <li>Patient confidentiality including health records should be at all times maintained</li> </ul>
Live transmission of surgery	The Royal Australian and New Zealand College of Ophthalmologists	2013	Position statement	<p>The use of pre-recorded video should be used over live transmission in all circumstances. Exceptions include:</p> <ul style="list-style-type: none"> <li>Thorough analysis of the 17-point list detailed in the position statement has been undertaken prior to the procedure</li> <li>The conclusion drawn from consideration from each of the points weigh in favour of the patient's best interests</li> <li>Analysis of each factor has been recorded and distributed to the patient, surgeon, organisers and operational facility</li> <li>Approval needs to be obtained from the RANZCO president, which must be in writing with a copy of the analysis</li> </ul>	<ul style="list-style-type: none"> <li>17-point checklist as outlined the position statement</li> </ul>	<ul style="list-style-type: none"> <li>Patient confidentiality including health records should be at all times maintained</li> </ul>

Table 2 (continued)

Name of the guidelines	Source	Year	Type/Methodology	Consent	Safety of patients in the OR	Protecting patient confidentiality
Advisory Opinion—Live Surgery	American Academy of Ophthalmology	2020	Expert opinion	<ul style="list-style-type: none"> <li>A patient's consent needs to be comprehensive and include risks of live surgery, the potential distraction of surgeon and patient, the possibility of breaches of confidentiality, alternatives to live surgery</li> <li>Coercion must be avoided, decision to withdraw needs to be respected</li> </ul>	<ul style="list-style-type: none"> <li>The surgeon needs to be familiar with the equipment prior to the LBSP</li> <li>The surgeon needs to be competent at the procedure being performed</li> <li>There needs to be suitable patient selection</li> </ul>	<ul style="list-style-type: none"> <li>The consent process needs to include the increased risk of breach of confidentiality; special consideration should be given to maintaining the confidential relationship between the physician and patient</li> </ul>

surgical events. They found that participants consistently reported that live events were of more educational value than pre-recorded videos. Participants felt that they acquired practical tips which they can apply to their own practice to a greater extent than in pre-recorded videos. Also, the interactive nature of the live surgery meant that they were more alert and engaged throughout. In contrast, Legemate et al. explored the views of urologists and participants in an educational event where LBSP was used, as well as pre-recorded unedited videos. Participants felt overall the education value was similar and a substantial percentage of the surgeons performing the LBSP reported that they felt that live surgery did not provide optimal circumstances for patient safety. Therefore, the authors advocated the use of more pre-recorded unedited videos [34].

### Patient safety

Patient safety was the main focus of this review and it was addressed by the success of the procedure and or the complication rate. In this review, we found almost one-third of the papers reported inferior outcomes with LBSP such as less favourable oncological outcomes [7], failure to complete the procedure endoscopically (partial success in 35 cases [8.6%] and complete failure in 24 cases [5.9%] as reported by Liao et al.; partial success in 6 cases [12%] and failure in 8 cases [15%], as reported by Ridditid et al.). In the series reported by Ruiz de Gordejuela et al., 6 patients required early re-operation and at follow-up 11 required revision. These inferior outcomes are noteworthy as they will have impacted significantly on patient care. The lack of success in endoscopic procedures will have resulted in repeat procedures with associated risks and in the case of outcomes reported by A. G. Ruiz de Gordejuela et al., the greater rate of revision surgery and complications will have worsened patient outcome. The greater rate of positive surgical margins should be emphasised as an area of concern as going forward this may adversely affect the oncological outcome for the patient.

These patient safety concerns have led some institutions to ban the use of LBSP in their meetings, such as the American College of Surgeons and the American College of Obstetricians and Gynaecologists. [3] Others such as the Royal Australian and New Zealand College of Ophthalmologists (RANZCO) have advised its use only in exceptional circumstances and have set out a checklist of points to be analysed prior to approval. In all other cases pre-recorded video is the preferred option.

It should be noted that a large proportion of LBSP remains unreported. Therefore, there is no rigorous analysis of patient outcomes and hence the level of patient safety remains unknown in these events. There may also be reluctance to report on events that show inferior patient outcomes.

		Risk of bias domains							
		D1	D2	D3	D4	D5	D6	D7	Overall
Study	Ogaya-Pinies et al	-	+	+	-	-	+	-	-
	Ramirez-Backhaus et al	-	-	+	+	-	+	-	-
	Gordejuela et al	X	-	-	X	X	+	-	X
	Mullins et al	-	+	-	+	-	-	-	-
	Itam et al	-	-	+	-	X	-	-	X
	Eliyahu et al	X	-	+	+	X	+	-	X
	Schmit et al	-	+	-	-	-	-	-	-
	Liao et al	-	+	-	-	-	+	+	-
	Ridtitid et al	-	+	-	X	-	-	-	X
	Franke et al	-	-	-	-	-	-	-	-
	Seeburger et al	-	+	-	+	-	+	-	-
	Legemate et al	-	+	-	-	X	-	-	X
	Rocco et al	-	-	+	+	-	-	-	-

Domains:  
D1: Bias due to confounding.  
D2: Bias due to selection of participants.  
D3: Bias in classification of interventions.  
D4: Bias due to deviations from intended interventions.  
D5: Bias due to missing data.  
D6: Bias in measurement of outcomes.  
D7: Bias in selection of the reported result.

Judgement  
X Serious  
- Moderate  
+ Low

**Fig. 2** Risk of bias (ROBINS-1)

This, along with the availability of alternatives to LBSP, may have discouraged some surgical societies from adopting its use.

These studies highlighted a number of concerns with LBSP which can be of significant impact on patient care and outcome. This highlights the stressing need for formal regulation of LBSP and developing a quality assurance framework that encompass dedicated consenting, maintaining confidentiality as well as a reporting on operative and postoperative outcomes for patients involved in LBSP. Additional, further studies are required to develop objective evaluation of the potential educational values of these events and translate these benefits into a safer environment

such as the use of pre-recorded unedited videos to minimise patient harm.

The potential negative impact of live surgery broadcast can be explained by a number of factors including, surgeons, fatigue, operating with unfamiliar teams and equipment in addition to the pressure to perform in front of a large audience.

Khan et al. explored LBSP from the view point of the surgeons performing the procedures. A small proportion of surgeons reported significant anxiety and reduced surgical quality when performing LBSP. This proportion increased significantly when LBSP was being performed in a foreign institution [35]. Finch et al. explored surgeons' views on

the educational value and safety of LBSP versus ‘As-live unedited surgical broadcast’ (ALB). The educational value was felt to be similar between both formats but it was felt there are greater patient safety benefits with ALB. Also of note respondents were significantly less likely to recommend themselves, a relative or friend to be a patient in LBSP [36].

In order to ensure safety at events with LBSP, surgical societies and institutions have published 14 guidelines and frameworks to maximise patient safety. While there are a small number of societies who outright ban LBSP at their meetings [3], a larger proportion note the educational value and advise operating surgeons and physicians to work in the scope of the guidelines in order to uphold patient safety as the priority.

### Consent

This review has also compared the outcomes of the 13 original studies against the recommendations from the summary of 14 prior guidelines and position statements. Although there is unanimous agreement among all the published guidelines for the need to have a dedicated consent process for LBSP, this was not the case when the 13 papers were reviewed. This highlighted the need to improve the quality of reporting on the consent process during LBSP, stating the separate risks of being involved in live surgery, the potential added risks such as surgeon distraction and delays due to transmission.

### Patient confidentiality

This review has also highlighted an important point related to protection of patients’ confidentiality during LBSP. This was clearly stated in all guidelines but not robustly reported on by the 13 studies. Standardisation of reporting on these important ethical matters in LBSP manuscripts should be an essential requirement to reassure the surgical community that these ethical standards of maintaining patient confidentiality are upheld throughout the LBSP.

Overall, there was a lack of recommendation on standardised approach of reporting on LBSP including the outcomes across the 14 published guidelines and positions statements. This needs to be a requirement in order to evaluate the safety of LBSP. This has been supported by the EAU, which has an established LBSP registry. This includes an application form as well as a check list which incorporates a wide range of requirements such pre-operative checks (selection of surgeon, consent and preparation of the patient), intraoperative (personnel, presence of moderators) and postoperative care (entering outcomes into the EAU live surgery registry, daily dedicated ward round and communication with the operating surgeon if any deviations occur).

This study has a number of limitations. We acknowledge that number of the studies in this review were modest with no randomised controlled trials and have moderate risk of bias in the quality assessment criteria. However, the 13 studies included a considerable sample size with some comparing LBSP to a matched controlled group. Secondly, we acknowledge that not all live surgical procedures broadcast are reported in the literature, which limits the generalisability of this review and the ability to capture key data to analyse the true educational value and safety of LBSP. Additionally, we conducted this review only on English-language studies and relevant articles in other languages may have been missed. Furthermore, most of the included studies did not report on fundamental issues such as measuring the potential educational values vs. the potential risk of LBSP. It was therefore not possible to draw a conclusion based on these reports. Finally, it was not possible in this synthesis to produce a meta-analysis due to the heterogeneity in reporting outcomes and complications among the included studies.

Nevertheless, this review has heightened a number of points in relation to the relevance of LBSP as part of virtual teaching curriculum during and post the pandemic. First, adherence to a high level of standards during LBSP must be maintained during and after the broadcast including maintaining patient confidentiality and reporting on patient outcomes. Secondly, there are logistical issues with conducting LBSP and the educational values must be balanced with those concerns including patient safety and confidentiality. Alternative teaching ways should also be explored such as streaming pre-recorded unedited videos, allowing the audience to see the procedure being performed while also gaining useful insights on how the surgeon deals with unexpected events, while minimising the risk by being outside the environment of a live surgical event. Finally, there is a need to study the role and potential impact of live demonstration on simulation models such as human cadavers, which could enhance the teaching experience without impacting on patient safety.

### Conclusions

Live Broadcast of Surgical Procedures can be of educational value but patient safety and outcomes may be compromised. Further research is required to develop a standardised framework of reporting on live surgery and its outcomes from an ethical and patient safety perspective.

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