Live surgery of colorectal endometriosis broadcasted from a surgeon’s routine operating theater is not associated with higher complications rate

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Abstract
Introduction: Although live surgeries are routinely included in surgical congress programs, they are the subject of an ongoing debate in terms of patient safety and teaching value. The goal of our study was to assess the risk of postoperative complications related to live surgery broadcast from the surgeon’s routine theater, in patients managed for deep endometriosis infiltrating the digestive tract.

Material and methods: We report a retrospective comparative study, enrolling women managed for colorectal endometriosis by a gynecologic surgeon, from September 2013 to March 2020 in two referral centers. We compared the rate of postoperative bowel fistula in women managed during live surgery in the routine operating theater, with that observed in women for whom surgery was not broadcast.

Results: Among 813 women, 33 (4.1% of cases) underwent surgical procedures transmitted live to various conference rooms located outside the hospital and were compared with 780 patients who underwent non-broadcast surgery. Women’s age, body mass index, past surgical and obstetrical history, and major preoperative complaints were comparable. Cases presented with impaired constipation score, more frequent sciatic pain, and infiltration of the vagina, whereas overall revised American Fertility Society classification scores were more severe in controls. The rate of rectal nodules over 3 cm in size was comparable between the two groups (72.7% in cases vs. 72.1% in controls). Operative time was also comparable (153 ± 52 minutes vs. 148 ± 79 minutes). Cases were more frequently managed by disk excision of rectal nodules (63.7% vs. 30.3%), and more frequently involved the sacral plexus (18.2% vs. 7.3%). Postoperative complications were comparable between the two groups, in terms of bowel fistula (3% in the live surgery group vs. 4.1% in controls), pelvic abscess requiring secondary laparoscopy (3% vs. 4.9%), or bladder dysfunction requiring self-catheterization after discharge (6.1% vs. 5.3%).

Abbreviations: GIQLI, gastrointestinal quality of life index; KESS, Knowles-Eccersley-Scott Symptom Questionnaire.
1 | INTRODUCTION

Live surgery refers to surgical procedures followed by persons who are not members of the surgeon’s team from a conference room separate from the operating theater and who interact with the surgeon during the procedure. Physicians attending the live surgery transmission can follow the whole procedure, listen to the surgeon’s explanations, and comment or ask questions about the different steps of the surgery. Although live surgeries are routinely included in surgical congress programs for all specialties, they are the subject of an ongoing debate between defenders and opponents of live surgery.1 Defenders argue that live surgeries have a didactic role, allowing physicians to follow a procedure carried out by expert surgeons in real time. The surgeon is able to provide answers to questions, explain steps, and give advice concerning the surgery.2,3 Opponents emphasize that live surgeries are often carried out in foreign operating theaters close to congress venues, where surgeons perform surgery using different devices, on patients they have not met before surgery, and with an unknown team who may speak another language; conditions that are far from ideal, even for an expert surgeon. A presumed higher risk of complications relating to this practice has led some surgical societies to ban live surgeries from meetings.1,4,5

Live surgery can also be performed by the surgeon in his/her own operating theater with transmission to a conference room located in another country or continent.6,7 The surgeon is therefore able to demonstrate complex surgeries, while maintaining the best possible conditions for patients, and avoiding the above-mentioned difficulties. The surgeon is, however, unlikely to be able to attend the congress after the surgery or to pursue discussions with those who watched the procedure, particularly when the conference is held abroad.

The goal of our study was to compare the rate of major postoperative complications in women managed during live surgery for complex laparoscopic procedures such as the excision of deep endometriosis infiltrating the rectum or the sigmoid colon by an experienced surgeon, in a routine operating theater, with that observed in women for whom surgery was not broadcast.

2 | MATERIAL AND METHODS

We performed a retrospective comparative study, including women managed for deep infiltrating endometriosis of the rectum or the sigmoid colon from September 2013 to March 2020, by a gynecologic surgeon (H.R.) in two referral centers for endometriosis: Rouen University Hospital, France (June 21, 2013 to June 20, 2018) and Clinique Tivoli-Ducos, Bordeaux, France (September 7, 2018 to March 13, 2020). The inclusion period began in the month of the first live surgery for deep endometriosis of the colon and rectum, performed in the surgeon’s routine operating theater with live transmission to an international meeting, and finished at lockdown because of the coronavirus disease 2019 pandemic. We included all patients managed for deep endometriosis infiltrating muscular, submucosal, or mucosal layers of the rectum and/or the sigmoid during this period, by the gynecologic surgeon (H.R.), with or without the help of general surgeons. A live surgery was defined as a procedure broadcast to a surgical meeting, attended by surgeons and other physicians who had the opportunity to directly interact with the surgeon, ask questions or comment during the surgery.

The gynecologic surgeon preoperatively examined all patients and questioned them on past medical and surgical history and baseline complaints. He also decided on the preoperative assessment, which was performed by radiologists with experience in deep endometriosis and included pelvic MRI, endorectal/transvaginal ultrasound, and, if required, computed tomography-based virtual colonoscopy. These imaging techniques enabled precise assessment of colorectal nodule characteristics and identification of associated localizations involving the vagina, uterosacral ligaments, ovaries, fallopian tubes, diaphragm, urinary tract, pelvic nerves, etc, allowing the gynecologist to understand potential relations between disease localizations and patient symptoms and provide personalized surgical management. Surgical details were discussed with patients and their families, who then made an informed choice. The surgeon more frequently planned live surgeries in cases of unusual localizations of the disease or those that enabled demonstration of a specific technique, such as removal of rectal nodules by disk excision or excision of deep parametria nodules with sacral plexus involvement. Patients were informed and consented to their surgeries being filmed and broadcast.

Conclusions: Performing laparoscopic management of colorectal endometriosis with live transmission of surgery from a surgeon’s routine operating theater, is not related to a higher risk of major postoperative complications.

KEYWORDS
bowel endometriosis, endometriosis, complication, experience, fistula, surgery

Key message
Performing laparoscopic management of colorectal endometriosis with live broadcasting of surgery from a surgeon’s routine operating theater is not related to a higher risk of major postoperative complications.
All patients, cases and controls, followed a 5-day preoperative residue-free diet and used a bowel preparation 1 day before surgery. In all patients, antibiotics were systematically administered 30 minutes before incision, but only prolonged after surgery in rare circumstances, such as intra-abdominal bowel content spillage. All surgical procedures were carried out laparoscopically. Surgical procedures that included shaving, disk excision, or colorectal segmental resection to remove deep endometriosis nodules infiltrating the rectum and/or the sigmoid colon, are available for review. Shaving was proposed when complete excision did not require opening the bowel lumen and was performed by the gynecologist, without assistance from general surgeons. Disk excisions were carried out using a combined laparoscopic and transanal approach, using either a circular stapler (a technique used by numerous teams worldwide) or a semi-circular stapler (the Rouen technique, a more recent and less frequently used method for removal of large nodules infiltrating the lower rectum). During this procedure, the presence of colorectal surgeons was required to perform rectal sutures using transanal staplers. Segmental resection was performed using a procedure commonly employed by other teams, during which the gynecologist removed the rectal specimen and placed the end-to-end anastomosis (EEA) stapler anvil in the proximal segment of the colon, followed by colorectal anastomosis carried out by colorectal surgeons. In cases of multiple bowel nodules, the aforementioned techniques could be associated, to preserve healthy bowel located between colorectal surgeons. Additional procedures were used to remove deep endometriosis nodules responsible for concomitant involvement of vagina, bladder, ureters, diaphragm, or sacral plexus. During the non-televized procedures, the surgeon routinely had students and fellows in the operative theater and normally talked continuously during the surgery.

Throughout the live surgery, via a microphone, the surgeon was able to explain key steps and methods used, as well as answer questions put by the audience. Conference delegates were able to follow the procedure, both intra-abdominally (via the laparoscopic view) and in the operating theater (filmed from the ceiling). Loudspeakers in the operating theater facilitated interaction between the surgeon and the audience. Live surgeries were transmitted using OR1 equipment (Karl Storz SE & Co, Tuttingen, Germany), a video management system that includes a videoconferencing codec enabling point-to-point broadcasts with full HD resolution. Some live surgeries from the Clinic Tivoli-Ducos were broadcasted via a Lifesize virtual meeting room, which allowed multiple correspondents to connect from a web browser from any device (PC, Mac, smartphones, tablets).

Postoperative assessment of blood values of C-reactive protein and white blood cells was routinely performed from days 3 to 6. When patients presented fever with temperature more than 38.2°C, or increases in either C-reactive protein or white blood cells for two consecutive days, clinical examination and emergency computed tomography with barium enema were performed to rule out anastomotic leakage, rectovaginal fistula, pelvic abscess, or infected pelvic hematoma. If required, emergency secondary laparoscopy and a rectal intraoperative air bubbles test were then performed. In patients with bowel leakage, an emergency stoma was created. In such cases, rectal enema was planned 8 weeks after the procedure to rule out rectovaginal fistula and stoma closure was carried out 2–3 months after surgery. Patients with rectovaginal fistula received secondary surgical management by a vaginal, transanal, or abdominal approach.

Patient preoperative data, intraoperative findings, main postoperative procedures, and follow up were prospectively recorded in the North-West Inter-Regional Female Cohort for Patients with Endometriosis (CIRENDO) database by dedicated clinical research technicians (ClinicalTrials.gov NCT02294825). Standardized gastrointestinal questionnaires were used to assess preoperative and postoperative digestive function: the Gastrointestinal Quality of Life Index (GIQLI), the Knowles-Eccersley-Scott Symptom Questionnaire (KESS), and the WEXNER scale for anal continence.

The primary end point of the study was the occurrence of bowel fistula, defined by postoperative opening of the bowel lumen into the abdomen or the vagina. Bowel fistula may occur following bowel shaving as the result of bowel wall necrosis, but was usually the result of leakage from the stapled line required for bowel repair after disk excision, or from performing colorectal anastomosis after segmental resection. Our primary hypothesis stated that the risk of bowel fistula would have not been increased in patients managed in live surgery. Secondary outpoints are pelvic abscess requiring secondary laparoscopy, bladder dysfunction requiring self-catheterization after discharge, as well as major complications recorded in our database and occurring during the first postoperative month.

### 2.1 Statistical analyses

Statistical analysis was performed using Stata 11.0 Software (Stata Corporation). Qualitative variables were expressed in terms of frequency and percentages, and continuous quantitative variables in mean and standard deviation. We compared patients who underwent surgery with live broadcasting and patients who underwent non-broadcast procedures using Fisher’s exact test for categorical variables and the Student t test for continuous variables. When categorical variables had more than two categories, we used the Freeman-Halton extension of the Fisher exact probability test. To avoid unjustified multiplication of statistical tests, only the three most frequent major complications were compared. Logistic regression models were used to identify the independent relation between various risk factors and the primary end point. A p value less than 0.05 was considered statistically significant.

### 2.2 Ethical approval

Prospective recording of data was approved by the French authority Advisory Committee on Information Processing in Healthcare
3 | RESULTS

From September 2013 to March 2020, 813 patients met the inclusion criteria and were enrolled in the study. For 33 (4.1%) patients, the surgical procedure was fully live broadcast to a conference room located in France, Germany, the USA, Spain, Switzerland, the Czech Republic, Hungary, Russia, Romania, Turkey, Israel, Egypt, or India. In two cases out of 33 (6%) technical problems led to a stuttered broadcasting stream but did not prevent attendees from fully following the surgical procedure. For one additional patient, transmission failed, and the patient was therefore included in the control group, as no interaction existed with the congress, and no questions or remarks were received during the procedure.

Table 1 presents patient characteristics. There were no statistically significant differences in patients’ age and body mass index, past medical and surgical history, or major baseline complaints. We observed a more severe KESS constipation score and more frequent sciatic pain in patients undergoing surgery with live broadcasting.

Table 2 presents intraoperative findings. Although rectal nodule size was comparable between the two groups, patients managed by surgery with live broadcasting presented with larger vaginal infiltration by deep endometriosis nodules. Disk excision was the most frequently (63.6% of patients) used procedure to treat rectal nodules. In three patients out of 33 (9.1%) rectal disk excision was associated with segmental resection of the sigmoid colon. The management of deep endometriosis involving the sacral plexus was significantly more frequent in the live surgery group. The lower revised American Fertility Society score in the live surgery group can be explained by the surgeon’s intention to perform live surgery in patients with fewer pelvic adhesions, as adhesions tend to render demonstration of surgery more difficult, particularly concerning the main surgical steps in management of deep endometriosis nodules. Performing live surgery was not found to be related to longer operative time (153 ± 52 minutes vs. 148 ± 79 minutes).

Gastrointestinal quality of life was overall improved 1 year after the surgery, and variations in KESS score (−3 vs. −4.1, p = 0.47) and GIQLI (14.5 vs. 9.3, p = 0.28) were comparable between the two groups. Major intraoperative complications were rare and exclusively recorded in the control group: one inadvertent section of the ureter (0.1%) and two hemorrhages originating from hypogastric veins requiring open surgery (0.3%). Postoperative complications occurring during the first postoperative month were comparable between the two groups (Table 3). Performing rectal disk excision associated with short sigmoid colon resection is related to higher risk of bowel fistula (9.7% vs. 0% after shaving, 6.8% after disk excision and 4.1% after colorectal resection, p < 0.001); however, none of the three patients who received this procedure during the live surgery had postoperative bowel fistula.

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Table 4 presents the results of the logistic regression model, which aimed to identify independent predictors for postoperative bowel fistula. Performing live surgery from the surgeon's routine operating theater was not found to be related to risk of bowel fistula (Table 3).

### Table 1 (Continued)

| Not live surgery N = 780 (95.9%) | Live surgery N = 33 (4.1%) | p |
|----------------------------------|-----------------------------|---|
| GQIL (mean ± SD)                 |                             |   |
| Wexner score for anal continence |                             |   |
| Loss of gas more frequently than 1/week | 124 (93.9) | 8 (6.1) | 0.36 |
| Loss of liquid stools more frequently than 1/week | 17 (100) | 0 | 1 |
| Loss of solid stools more frequently than 1/week | 6 (100) | 0 | 1 |
| Wears sometimes, usually, or always | 24 (92.3) | 2 (7.7) | 0.29 |
| Lifestyle alteration sometimes, usually, or always | 89 (96.7) | 3 (3.3) | 1 |
| Unable to defer defecation more than 10 min | 335 (96.3) | 13 (3.7) | 0.72 |

#### Other baseline complaints

| Hydronephrosis | 46 (97.9) | 1 (2.1) | 0.71 |
| Digestive tract subocclusion/occlusion | 78 (98.7) | 1 (1.3) | 0.36 |
| Kidney atrophy <10% residual activity on DMSA scintigraphy | 6 (100) | 0 | 1 |
| Severe bladder dysfunction | 15 (88.2) | 2 (11.8) | 0.14 |
| Sciatic pain | 23 (79.3) | 6 (20.7) | 0.001 |
| Ascites | 3 (100) | 0 | 1 |

*Note: Lack of ability to defecate = normal status superior to 15 min. Abbreviations: GQIL, gastrointestinal quality of life index; explores overall quality of life related to digestive tract function; range 0–144; median value in normal healthy population is 124; the lower the score, the lower the gastrointestinal quality of life; KESS, Knowles-Eccersley-Scott Symptom questionnaire; explores the constipation; range from 0 to 39; values over 7 are related to constipation status; the higher the score, the more severe the constipation; WEXNER score, explores the anal continence; 0 represents normal anal continence, the higher the score, the more severe the anal incontinence.

*aAmong patients who have had sexual intercourse."

### Table 2 Intraoperative findings and surgical procedures

| Not live surgery N = 780 (95.9%) | Live surgery N = 33 (4.1%) | p |
|----------------------------------|-----------------------------|---|
| Surgical route                   |                             |   |
| Laparoscopic surgery             | 769 (95.9) | 33 (4.1) | 1 |
| Laparoscopy followed by open route | 11 (100) | 0 |   |
| Operative time (min, mean ± SD)  | 148 ± 79 | 153 ± 52 | 0.73 |
| Multidisciplinary team           |                             |   |
| With a general surgeon           | 564 (95.6) | 26 (4.4) | 0.55 |
| With a urologist                 | 45 (95.7) | 2 (4.3) | 1 |

#### Intraoperative findings

| Deep endometriosis nodule localization | 121 (96.8) | 4 (3.2) | 0.81 |
| Left uterosacral ligament            | 56 (87.5) | 8 (12.5) | 0.003 |
| Right uterosacral ligament           | 31 (100) | 0 | 0.63 |
| Both uterosacral ligaments           | 184 (94.9) | 10 (5.2) | 0.40 |
| Rectovaginal space                   | 521 (96.1) | 21 (3.9) | 0.71 |
| Revised American Fertility Society score (mean ± SD) | 69 ± 38 | 47 ± 37 | 0.001 |
| Douglas obliteration                 |                             |   |
| No                                 | 56 (98.3) | 1 (1.7) | 0.27 |
| Partial                            | 187 (94) | 12 (6) |
| Complete                           | 537 (96.4) | 20 (3.6) |

#### Digestive tract infiltration

| Sigmoid colon | 305 (97.4) | 8 (2.6) | 0.10 |
| Rectum        | 713 (95.8) | 31 (4.2) | 1 |
| Ileum         | 96 (99) | 1 (1) | 0.16 |
| Appendix      | 126 (96.9) | 4 (3.1) | 0.80 |

#### Rectal nodule size

| <1 cm (ENZIAN C1) | 64 (97) | 2 (3) |
| 1–3 cm (ENZIAN C2) | 153 (95.6) | 7 (4.4) |
| >3 cm (ENZIAN C3) | 483 (95.8) | 21 (4.2) |

#### Vaginal infiltration

| No | 428 (98.2) | 8 (1.8) |
| ≤1 cm (ENZIAN A1) | 44 (97.8) | 1 (2.2) |
| 1–3 cm (ENZIAN A2) | 86 (92.5) | 7 (7.5) |
| >3 cm (ENZIAN A3) | 222 (92.9) | 17 (7.1) |

(Continues)
Our study did not find a statistically significant relation between risk of intraoperative or major postoperative complications and transmission of live surgery that involves complex surgical procedures for colorectal endometriosis, performed by the surgeon in his usual operating theater. Furthermore, transmission of surgery was not related to longer operative time. In our case series, the surgeon planned surgical management based on patient informed choice, and live broadcasting of the procedure to be demonstrated, despite its complexity, such as disk excision of rectal nodules or removal of deep endometriosis involving parametria and sacral plexus. Hence, patient selection for live surgery was related to the surgeon's objectives, notably to teach the techniques for disk excision of rectal nodules and the 10-step dissection of deep endometriosis nodules.

**TABLE 2** (Continued)

| Procedure                                      | Not live N = 780 (95.9%) | Live surgery N = 33 (4.1%) | p     |
|------------------------------------------------|--------------------------|----------------------------|-------|
| Diaphragmatic localizations (ENZIAN FO)         | 131 (95.6)               | 6 (4.4)                    | 0.81  |
| Surgical procedures on digestive tract          |                          |                            |       |
| Shaving                                        | 216 (96.9)               | 7 (3.1)                    | 0.55  |
| Disk excision                                  | 231 (91.7)               | 21 (8.3)                   | <0.001|
| Procedure of disk excision                     |                          |                            |       |
| Height of disk excision (cm)                    | 7.5 ± 5.4                | 6 ± 2.4                    | 0.23  |
| Diameter of disk excision (cm)                  | 4.6 ± 1.3                | 4.6 ± 1.1                  | 0.90  |
| Segmental resection                             | 361 (97.8)               | 8 (2.2)                    | 0.01  |
| Height of colorectal anastomosis (cm)           | 11.3 ± 7.9               | 14.9 ± 6.6                 | 0.21  |
| Diverting stoma                                 |                          |                            | 0.59  |
| No                                             | 597 (96.3)               | 23 (3.7)                   |       |
| Colostomy                                      | 144 (94.7)               | 8 (5.3)                    |       |
| Ileostomy                                      | 39 (95.1)                | 2 (4.9)                    |       |
| Ileocolic resection                             | 53 (100)                 | 0                          | 0.16  |
| Resection of the cecum                          | 16 (100)                 | 0                          | 1     |
| Segmental resection of the ileum                | 25 (100)                 | 0                          | 0.62  |
| Surgical procedures on urinary tract            |                          |                            |       |
| Bladder resection                               | 74 (94.9)                | 4 (5.1)                    | 0.55  |
| Resection of the ureter and anastomosis         | 9 (100)                  | 0                          | 1     |
| Resection of the ureter and re-implantation into the bladder | 11 (91.7) | 1 (8.3) | 0.39  |
| Other surgical procedures                       |                          |                            | 0.59  |
| Hysterectomy                                    |                          |                            |       |
| No                                             | 678 (95.8)               | 30 (4.2)                   |       |
| Total hysterectomy                              | 37 (100)                 | 0                          |       |
| Total hysterectomy and large colpectomy         | 65 (95.6)                | 3 (4.4)                    |       |
| Surgery of diaphragmatic nodules                | 29 (96.7)                | 1 (3.3)                    | 1     |
| Dissection/Excision of sacral roots/sciatric nerve endometriosis lesions | 55 (90.2) | 6 (9.8) | 0.03  |

**TABLE 3** Major postoperative complications

| Major postoperative complications            | Not Live N = 780 (%) | Live N = 33 (%) | p     |
|----------------------------------------------|----------------------|----------------|-------|
| Bowel fistula                                 | 32 (4.1)             | 1 (3)          | 0.99  |
| Bladder dysfunction requiring self-catheterization after discharge | 41 (5.3) | 2 (6.1) | 0.69  |
| Pelvic abscess requiring secondary laparoscopy | 38 (4.9) | 1 (3) | 0.99  |
| Other major complications (Clavien Dindo 3b) |                      |                |       |
| Major rectorrhagia requiring secondary procedure and/or blood transfusion | 7 (0.9) | 1 (0.1) |       |
| Small bowel necrosis                          | 1 (0.1)              |                |       |
| Small bowel occlusion requiring laparoscopy   | 5 (0.6)              |                |       |
| Stomal prolapse                                | 9 (1.2)              |                |       |
| Fistula of ureteroneocystostomy               | 1 (0.1)              |                |       |
| Crush syndrome of the leg                     | 2 (0.3)              |                |       |
| Hemoperitoneum                                | 5 (0.6)              |                |       |
| Fistula between uterine artery and uretero-ureteral anastomosis, managed by embolization | 1 (0.1) | |       |
| Stenosis of the ureteroneocystostomy          | 1 (0.1)              |                |       |
| Pelvic hematoma                                | 1 (0.1)              |                |       |
| Vesicovaginal fistula                         | 1 (3)                |                |       |
| Pyelonephritis                                | 7 (0.9)              |                |       |
| Hydronephrosis requiring JJ stent insertion   | 1 (0.1)              |                |       |
| Bladder fistula                               | 2 (0.3)              |                |       |
| Ovarian abscess                               | 2 (0.3)              |                |       |
| Ureteral stenosis                             | 1 (0.1)              |                |       |
| Ureteral fistula                              | 3 (0.4)              |                |       |
| Pyosalpinx                                    | 1 (0.1)              |                |       |
| Colonic occlusion                             | 2 (0.3)              |                |       |

**4** | **DISCUSSION**

Our study did not find a statistically significant relation between risk of intraoperative or major postoperative complications and
of the parametria and sacral plexus.\textsuperscript{25} Broadcasting live surgery from a surgeon’s usual operating theater appears to be as safe as non-broadcast procedures for similar patients.

Our study has some limitations. Our retrospective design may be responsible for the loss of various data (past events, baseline unusual complaints, minor complications), which were not collected in the initial cohort’s questionnaires. As our cohort only enrolled women managed in the surgeon’s clinic and usual operating theater, this study does not provide information on risks related to live surgeries performed by visiting surgeons. A further limitation concerns comparison between cases and controls. The surgeon more frequently planned live surgeries in cases of unusual localizations of the disease or those that enabled demonstration of a specific technique, such as removal of rectal nodules by disc excision or excision of deep parametria nodules with sacral plexus involvement. This choice could have led to an increase in the prevalence of complications such as bladder dysfunction or bowel fistula in cases. The two groups are unbalanced in terms of number of included patients, leading to a potential loss of statistical power for detecting small differences between the groups. Only one surgeon performed the procedures, resulting in a disputable extrapolation of his data and outcomes. The study included consecutive patients managed over a period of time, and did not use a preliminary sample size calculation to improve the power of the statistical analysis.

Our study also has some strengths. It investigates a specific issue, that of live surgeries, a practice defended by some surgeons and criticized by others. We report on a large series of patients managed for complex gynecologic procedures for deep endometriosis infiltrating the rectum or the sigmoid colon only, by a highly experienced surgeon. Inclusion criteria favored a homogeneity of surgical techniques associated with particular care given to spare healthy bowel and nerves. Data were prospectively collected by dedicated clinical researchers to ensure accuracy and validity of results. Postoperative complications were thoroughly recorded whereas digestive function and patient symptoms were carefully assessed using standardized gastrointestinal questionnaires.

Live surgeries have been used by surgeons over the centuries.\textsuperscript{1} This teaching took place in amphitheaters where the rules of asepsis were either unknown or not applied and depending on the size of the venue, could be attended by large numbers of surgeons. Technical advances in video and streaming at the end of the 20th century brought considerable changes to live surgery\textsuperscript{26,27} and a transition from small groups of observers standing in a quiet operating room, to a large audience continuously interacting with the surgeon and surgical team via cameras and microphones.\textsuperscript{28} With the help of a mediator who remains in constant contact with the surgeon, questions can be asked during surgical procedures, with immediate feedback. Furthermore, development of laparoscopy provides transmission with high-definition views, enabling delegates to see the procedure as clearly as the surgeon.\textsuperscript{28}

Presenting a complete surgical procedure for teaching purposes while providing concomitant interaction between the surgeon and the audience may be provided in three different ways: (a) live surgery performed by visiting surgeons in a hospital close to the congress

| Procedure on the rectum          | Total N = 813 (100%) | Fistula N = 33 (4.1%) | OR  | 95% CI     | p    |
|----------------------------------|----------------------|-----------------------|-----|-----------|------|
| Disk excision                    | 252 (31)             | 18 (7.1)              | 1   |           |      |
| Segmental resection              | 338 (41.6)           | 14 (4.1)              | 0.7 | 0.3–1.4   | 0.28 |
| Shaving                          | 223 (27.4)           | 1 (0.5)               | 0.1 | 0–0.5     | 0.007|
| **Live surgery**                 |                      |                       | 0.41|           |      |
| No                               | 780 (95.9)           | 32 (4.1)              | 1   |           |      |
| Yes                              | 33 (4.1)             | 1 (3)                 | 0.4 | 0.1–3.2   |      |
| **Vaginal infiltration**         |                      |                       | 0.12|           |      |
| No                               | 436 (53.6)           | 8 (1.8)               | 1   |           |      |
| <1 cm                            | 45 (5.5)             | 3 (6.7)               | 4.6 | 1.1–18.8  | 0.03 |
| 1–3 cm                           | 93 (11.4)            | 4 (4.3)               | 3.1 | 0.9–11.1  | 0.08 |
| >3 cm                            | 239 (29.4)           | 18 (7.5)              | 4.5 | 1.7–11.5  | 0.002|
| **Stoma**                        |                      |                       | 0.47|           |      |
| No                               | 619 (76.1)           | 20 (3.2)              | 1   |           |      |
| Yes                              | 194 (23.9)           | 13 (6.7)              | 0.7 | 0.3–1.7   |      |
| **Height of the rectal infiltration (N = 698)\textsuperscript{a}** |                      |                       | 0.51|           |      |
| ≥7 cm                            | 413 (59.2)           | 16 (3.9)              | 1   |           |      |
| <7 cm                            | 285 (40.8)           | 16 (5.6)              | 1.3 | 0.6–3     |      |

\textsuperscript{a}The variable “height of rectal infiltration” was available in only 698 patients and absent in 115 patients; the adjustment on this variable did not change the value of OR related to other risk factors.

### TABLE 4

Independent factors related to the probability of bowel fistula (logistic regression model)
venue; (b) live surgery performed at a surgeon's usual theater and broadcast to the congress venue; and (c) pre-recorded surgical procedures presented by the surgeon.

The most frequent type of live surgery is performed by visiting surgeons in a hospital located close to a congress venue. The main advantage lies in the fact that there are fewer technical challenges, with all procedures transmitted from one operating theater with a dedicated technical team to ensure broadcasting quality. Expert surgeons carrying out live surgery may also attend the congress before and after their procedure. There are, however, a number of disadvantages associated with this type of live surgery, notably that the presence of a large audience while working in new or different circumstances may put additional pressure on surgeons and increase the risk of unfavorable events and outcomes. Experts may face practical issues such as travel-related fatigue, language barriers, and limited consultation time with the patient. They may be unable to plan the surgery according to patient needs, expectations, and informed choice, compelled to rely on information on the patient’s condition and preoperative imaging assessment provided by the organizer and to put aside their usual practice. The surgeon may be uncomfortable using surgical instruments provided by the organizer, and encounter language barriers with operating room staff. In some cases, a procedure planned by an organizer may differ from what the surgeon would have chosen, or planned surgery time may be insufficient for the whole procedure. Finally, surgeons tend to leave a congress venue a few days after the live surgery and are unavailable to attend to the patient for immediate postoperative complications, and may not even be informed of them.

The second type of live surgery is broadcast from a surgeon's usual operating theater to the congress venue and presents many advantages. The surgeon can select the patient depending on the procedure he wishes to demonstrate and obtain patient informed choice and agreement for transmission. Other advantages include working in a familiar environment with a familiar team and maintaining greater control over surgical conditions, including estimation of operating time. Surgeons avoid travel-related fatigue and can communicate easily with the operative team. Further problems concern possible time differences, a scheduled time of broadcasting in the morning at a conference on one continent may correspond to performing surgery at night in the operative room and additionally the surgeon may not be able to join the congress.

The alternative to live surgeries is the presentation of a pre-recorded video by the surgeon. This presents clear advantages in terms of preparation, timing and reduction in potential fatigue and stress. This solution may also lead to reduced technical costs and facilitate interaction between the surgeon and the audience. However, low-quality filming or over-editing may lead to loss of information or lessen opportunities for discussion over techniques used and prevent the audience from fully visualizing the surgical procedure. Finally, should postoperative complications occur, they cannot be attributed to unusual circumstances associated with live surgery and the surgeon can attend the whole congress.

Several studies have attempted to assess complication rates recorded in patients managed with live surgery, most involving visiting surgeons for urologic or digestive tract diseases. In a study including 224 patients managed with live surgery, by experienced visiting surgeons, for urologic disease during 12 annual meetings of the Congresses Challenge in Laparoscopy and Robotics (CILR), 12 postoperative complications (5.4%) were recorded, requiring secondary surgical management (Clavien Dindo 3b). One patient died following a laparoscopic cystectomy, though the postoperative mortality rate for this surgical procedure varies in the literature at approximately 2%. Other studies did not reveal a higher risk of complication in live surgery when compared with conventional procedures in urology. A review of 36 case series found that low-risk procedures in live surgery were not associated with higher postoperative complications, but that their success rate appeared to be lower. Another case series including 107 patients managed mainly for bariatric surgery during 10 consecutive years in live surgery courses organized in Spain, revealed a higher complication rate when compared with that following conventional surgery. In a further single center comparative study, a higher overall complication rate was found for 39 patients managed by minimally invasive colorectal surgery broadcast live when matched with 39 controls. The suggested higher risk of complications associated with live surgery has led several surgical societies to discourage or stop live surgery by visiting surgeons.

Other studies have aimed to demonstrate that live surgeries at home, in a routine operating room, are not associated with increased postoperative risk. These studies support our results and suggest that broadcasting live surgery is a safe practice. Ogaya-Pinies et al found that the rate of complications of robot-assisted radical prostatectomy performed by an expert surgeon at home and transmitted to an external congress was zero. In the same way, Andolfi and Gundeti reported their experience in 22 robotic live surgeries for pediatric urologic diseases, which were performed at home with live transmission to various national meetings. They compared outcomes recorded in patients managed live with other conventional surgeries and observed better surgical outcomes associated with live surgery. These results are comparable to ours and most likely reflect the care taken to select patients suitable for live surgery; taking into account phenotype, lack of severe surgical antecedents or additional challenging circumstances, surgical procedure preparation, and the presence of highly skilled assistants and nurses.

Defenders of live surgery underline the educational value of seeing every step of a procedure, including seemingly minor details that may be edited out in other educational formats. The audience can see more details regarding exposure, set-up, interplay with assistants, and view how the team responds to anatomic or intraoperative challenges. Live surgery provides an immediacy not found in edited surgery and gives the audience access to ask questions not afforded by any other medium. Questions can be asked at every step of the procedure, and if required the surgeon can detail any steps. Studies reporting on the educational value of live surgeries are, however, scarce in the literature and no study has yet compared this value with that of pre-recorded surgical procedures.
Andolfi and Gundeti following 22 live surgeries broadcast from their usual operating theater, have proposed guidelines to ensure that live surgery remains a successful event with good postoperative outcomes. They emphasize that live surgery should only be performed by surgeons with high surgical volume and previous experience of live surgery, and at the surgeon's home institution with a familiar team to reduce risk of unforeseen circumstances. Live broadcasting should be moderated within the operating room by an assistant who serves as a filter between moderators in the audience and the surgeon. Direct discussion with the surgical team should be reserved for appropriate steps of the surgery only, to avoid distraction. Finally, the surgeon should feel able to stop the live broadcast if intraoperative events require all his concentration or increase stress levels.

It has been shown that patient anxiety during the diagnostic period is statistically decreased after the preoperative visit, particularly in women who seek out information on the internet and in those with high baseline anxiety. We completely agree with these findings. Preoperative information about the goal of the surgery, data about surgeon experience, main outcomes in the surgeon's own series of patients managed for the same localization, and information about the management of potential complications usually increase patient confidence regarding the likelihood of postoperative improvement. Furthermore, information about the broadcasting of their surgery to a congress where peers can follow the procedure, rather than being a source of worry for patients, instead underlines the extent to which the surgeon is both at ease performing the procedure and open to receiving peer analysis concerning the surgery performed.

To our knowledge, patient satisfaction in these circumstances has not yet been assessed. Patients managed by visiting surgeons are usually aware that the procedure is to be performed by an expert coming from away, assisted by their routine surgeon, with care and follow up to be provided by the latter physician. In these circumstances, it is likely that a patient managed by a visiting surgeon would be satisfied by the treatment proposed. As regards patients managed by the surgeon in his/her operating theater, their satisfaction is likely to depend more on the result of the surgery than on the broadcasting of the procedure.

Although the effectiveness of live surgical demonstrations at conferences remains controversial, live demonstrations of laparoscopic surgery provide opportunities for trainees to learn and develop skills used in laparoscopic surgery and for teaching of large groups, peer review by expert moderators, rigorous cross examination, and exchange of ideas. Broadcasting to large audiences does not physically interfere with the flow of the operating room or cause distraction for clinical staff. Currently there are no data to definitively demonstrate that live surgery broadcast from a surgeon's usual operating theater is associated with higher risk of intraoperative or postoperative unfavorable events, when compared with non-broadcast procedures. Although broadcasting live surgery from a surgeon's usual operating theater can be associated with technical challenges, we believe it is preferable to live surgery performed by visiting surgeons and presents more advantages than pre-recorded procedures.

5 | CONCLUSION

Our study suggests that live surgery from a surgeon's usual operating theater may not lead to a significant increase in bowel fistula rate, when compared with non-broadcast surgery, indicating that live surgery is a safe tool for conferences and teaching purposes. In the light of current opinion on live surgery performed by visiting surgeons, live surgery from a surgeon's routine theater, despite possible technical challenges, remains an attractive teaching method.

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HR and MP performed the study design and statistical analysis. HR and JM wrote the first draft of the report. BM, DF, MN, J-JT reviewed the manuscript. HR and LM checked data recording. All authors revised and contributed to the writing of the final manuscript and approved it for publishing.

CONFLICT OF INTEREST

HR reports personal fees from Plasma Surgical Inc., Ethicon EndoSurgery Inc., Olympus, Gedeon Richter, Karl Storz, and Nordic Pharma for participating in master classes. Other authors report no conflict of interest.

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