Surgical Endoscopy (2023) 37:5760–5765
https://doi.org/10.1007/s00464-023-10230-7

DYNAMIC MANUSCRIPT

Effects of wide-angle laparoscopy on surgical workflow in laparoscopic cholecystectomies

Zvi Ehrlich[1] · **Shirley S. Shapira**[2] · **Gideon Sroka**[3]

Received: 29 April 2023 / Accepted: 17 June 2023 / Published online: 26 June 2023
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2023

Abstract

Introduction Laparoscopy is now the gold standard approach to many surgical procedures thanks to its many advantages. Minimizing distractions is essential to a safe and successful surgery and an undisrupted surgical workflow. The SurroundScope, a wide angle (270°) laparoscopic camera system has the potential to decrease surgical distractions and increase workflow.

Methods Forty-two laparoscopic cholecystectomies were performed by a single surgeon, 21 with the SurroundScope and 21 with standard angle laparoscope. Video recordings of surgeries were reviewed for calculating the number of entries of surgical tools into the field of view, relative time of tools and ports viewed in surgical field and number of times camera was removed due to fog or smoke.

Results The usage of the SurroundScope resulted in a significantly lower number of entries to the field of view compared to the standard scope (58.50 versus 102; $P < 0.0001$). Usage of SurroundScope resulted in a significantly higher appearance ratio of tools, with a value of 1.87 compared to 1.63 for standard scope (P-value < 0.0001), and the appearance ratio of ports was also significantly higher, measuring 1.84 compared to 0.27 for the standard scope (P-value < 0.0001). In addition, the SurroundScope had to be removed and reinserted due to smoke or fog in only 2 cases (9.5%), compared to 12 cases (57.1%) in the standard scope group (P-value < 0.01).

Conclusions The SurroundScope camera system improves surgical workflow in laparoscopic cholecystectomy. This conceivably increase the safety of the operation due to the utilization of the wide-angle view and "chip on the tip" technology.

Keywords SurroundScope · Workflow · Laparoscopy · Cholecystectomy

Laparoscopy is now recognized as the preferred approach for numerous surgeries in many medical disciplines [1]. It has many advantages, such as smaller incisions, better visualization, reduced pain, reduced blood loss, shorter hospitalization and faster recovery and return to regular daily activity [2–4].

Laparoscopic cholecystectomy is a surgical procedure for removal of the Gallbladder and approximately 300,000 cholecystectomies are performed in the United States annually [5]. Common indications for cholecystectomy include biliary colic, acute\chronic cholecystitis, Gallbladder masses/polyps and Biliary dyskinesia. Manifestation of gallbladder disease may include but are not limited to right upper quadrant abdominal pain, fever, jaundice, nausea and vomiting. In recent years laparoscopy has become the gold standard approach to cholecystectomy. Possible complications are the procedure include bleeding, infection and injury to surrounding organs.

Surgical workflow is essential for a successful and safe surgery. Distractions and interferences within the operating room have been shown to disrupt the surgical workflow and may have a negative effect on safety and efficacy of surgeries [6]. It is thus beneficial to limit these to a minimum.

The SurroundScope (270Surgical), is a novel laparoscopic system which provides a 270° wide view to the surgeon [7]. Additionally, this system does not suffer from fogging and visualization can be achieved even when smoke is

✉ Zvi Ehrlich
ehrzmd@gmail.com

[1] Department of Obstetrics and Gynaecology, Shaare Zedek Medical Centre, Hebrew University Medical School, Jerusalem, Israel

[2] 270Surgical Ltd., Natanya, Israel

[3] Department of Surgery, Bnai Zion Medical Center, Technion - Israel Institute of Technology, Haifa, Israel

present during surgery (video 1), improving surgical workflow. This study aims to review further potential benefits to surgical workflow, associated with the SurroundScope wide angle view.

Materials and methods

All surgeries were video recorded for later analysis. All procedures were performed with four trocars. One supraumbilical for the camera, one lateral sub-costal for the gallbladder retraction, and two ports for the tools held by the surgeon: sub-xiphoid and medial sub-costal. We quantified surgical tool visualization as well as interruptions due to entry and exit of tools into the visual field during surgery. In addition, removal of the endoscope due to fog or smoke was also quantified.

This study uses the SurroundScope, a novel laparoscopic surgical system (510K K210104). The distal tip of its laparoscope is equipped with three cameras (central, left and right). The combination of these images produced on the 270System screen can be seen in Fig. 1, as well as the entire system and a schematic cameras' location of the scope's tip. Note, the central frame alone provides a wider than usual field of view (FOV) (95° angle vs 70° with standard laparoscopy). The additional two side frames provide the complete 270° FoV. The system is also designed to eliminate lens fogging and to improve visualization through smoke.

This study delves in a sub-analysis of comparative data from a prospective, open label study, conducted between March 2021 and October 2022 at Bnai-Zion Medical Center (BZ) in Haifa, Israel. Forty-two cholecystectomies were performed by a single surgeon. Twenty-one were performed with the SurroundScope, which provides a 270° angle view

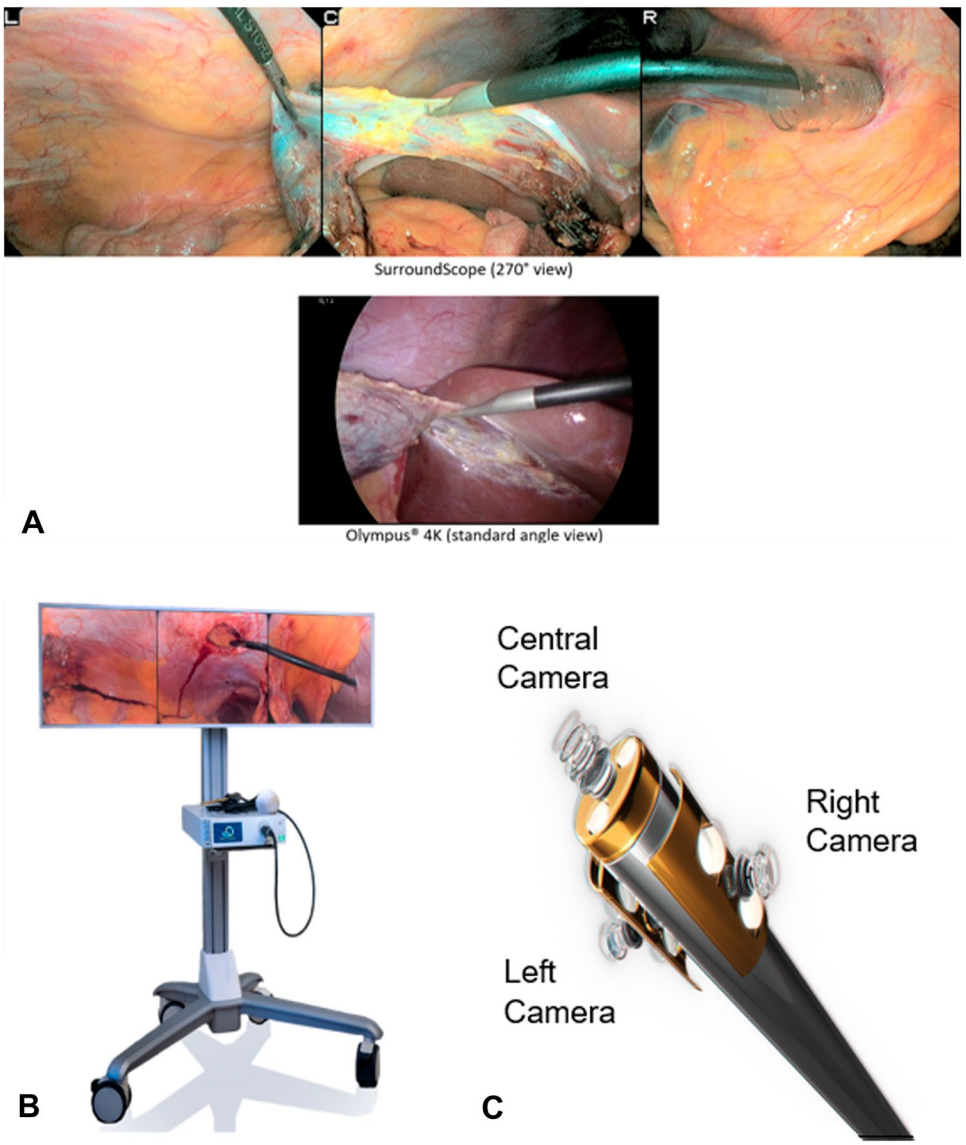

Fig. 1 The 270 laparoscopic system. **A** Laparoscopic view of the gallbladder retraction with wide angle scope vs. standard angle scope. **B** The entire system. **C** The tip of the scope incorporating three cameras (front, left and right)

(Fig. 1), and 21 with a standard view (70° angle view) laparoscope (Olympus 4K) (Fig. 1).

Recordings were analyzed by two independent reviewers who identified the timing when tools or ports entered or exited the FOV.

"Net Procedure Time" [Net PT] was defined as the duration of laparoscopic surgery, excluding time when the camera was removed during the procedure.

The duration of each instance when a tool or port appeared within the FOV was calculated by measuring the time from its entrance to the time of its exit ("Appearance Time" [AT]). The ratio between the total AT of tools or ports to the Net PT was calculated and was defined as the appearance ratio. As there were frequent instances when multiple tools or ports were simultaneously visible in the FOV, the cumulative duration of tools or ports within the FOV is longer than the procedure time, thus the ratio is higher than 1 and exceeds 100% of the laparoscopic time. The number of times the camera was removed and reinserted into the abdomen was recorded. Additionally, the surgeon evaluated the complexity level of the procedure, categorizing it as either Easy, Intermediate, or Complex. The usage of drains was captured.

All participants provided written informed consent. Study protocol was approved by institutional review board (IRB 0116-20-BNZ).

This study was registered with the NIH (NCT04651270).

Statistical analyses

Results were summarized in tabular format. Continuous variables were expressed as median and interquartile range [IQR]. Categorical variables were expressed as number and percentage (%). Comparisons AT and ratio were compared between scopes using Mann–Whitney test. Categorical variables were compared using Fisher's exact test.

Graphical representation of the appearance ratio is based on Box-plots (depicting groups of numerical data through their quartiles and whiskers indicating variability outside the upper and lower quartiles). A two-side *P* value less than 0.05 was considered to define statistical significance. Analyses were carried out using in R-4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) and IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0.1.1 Armonk, NY: IBM Corp.

Results

Of the 42 recordings reviewed, 41 complete recordings were available for analysis and 1 partial recording which began only after trocar placement. This video could be included in the assessment of the scope removals only, as the necessary data could be derived from the CRF. Patients in both groups didn't differ in age, BMI or gender (Table 1). Patients in the SurroundScope group had a significantly higher ASA scores. Level of complexity of the surgeries as defined by the surgeon were similar between the groups as well as drain placement.

The indications for cholecystectomy were also similar between groups and included at least one of the following for each patient: biliary cholic, acute cholecystitis, acute pancreatitis, cholangitis, and patients who had undergone endoscopic retrograde cholangiopancreatography (ERCP) due to a common bile duct stone (Table 1).

The usage of the SurroundScope resulted in a significantly lower number of entries to the FOV compared to the standard scope (58.50 versus 102; $P < 0.0001$) as shown in Table 2 and Fig. 2.

Figure 3 depicts two cholecystectomies, one performed using the SurroundScope and the other using a standard scope, which have similar durations. Each line in the figure represents a tool entering the FOV, resulting in a disruption. Clearly, used of the standard scope resulted in significantly more distractions during the procedure.

Table 1 Characteristics of patients undergoing laparoscopic cholecystectomies and indications for cholecystectomy

	SurroundScope ($n=21$)	Standard scope ($n=21$)	*P*-value
Gender			0.3408
Female	11 (52.4%)	15 (71.4%)	
Male	10 (47.6%)	6 (28.6%)	
BMI (median)	29.73	28.1	0.5212
Age (median)	62	66	0.6596
ASA			0.002
1	1 (4.8%)	7 (33.3%)	
2	13 (61.9%)	14 (66.7%)	
3	7 (33.3%)	0 (0.0%)	
Complexity			0.6767
Easy	13 (61.9%)	10 (47.6%)	
Intermediate	6 (28.6%)	8 (38.1%)	
Complex	2 (9.5%)	3 (14.3%)	
Surgical drain			0.3499
No	14 (66.7%)	10 (47.6%)	
Yes	7 (33.3%)	11 (52.4%)	
Indications[a]			
Biliary cholic	9 (42.9%)	10 (47.6%)	1
Acute cholecystitis	7 (33.3%)	5 (23.8%)	0.7337
Acute pancreatitis	2 (9.5%)	2 (9.5%)	1
Cholangitis	2 (9.5%)	4 (19.0%)	0.6628
Post-ERCP	5 (23.8%)	3 (14.3%)	0.6965

[a]Some patients had ERCP in addition to another indication

Table 2 Results of FOV entries, appearance ratio of tool and port and scope removals

	SurroundScope	Standard scope	*P*-value
Number of tool entries to the FOV	$n=20$	$n=21$	0.0064
Median (Q1, Q3)	58.50 (45.50, 90.25)	102.00 (64.00, 145.00)	
Appearance ratio of tools	$n=20$	$n=21$	<0.001
Median (Q1, Q3)	1.87 (1.79, 1.97)	1.63 (1.36, 1.74)	
Appearance ratio of ports	$n=20$	$n=21$	<0.001
Median (Q1, Q3)	1.84 (1.68, 1.97)	0.27 (0.21, 0.45)	
Number of scope removals due to smoke\fog	$n=21$	$n=21$	0.0025
1–10	2 (9.5%)	12 (57.1%)	
No	19 (90.5%)	9 (42.9%)	

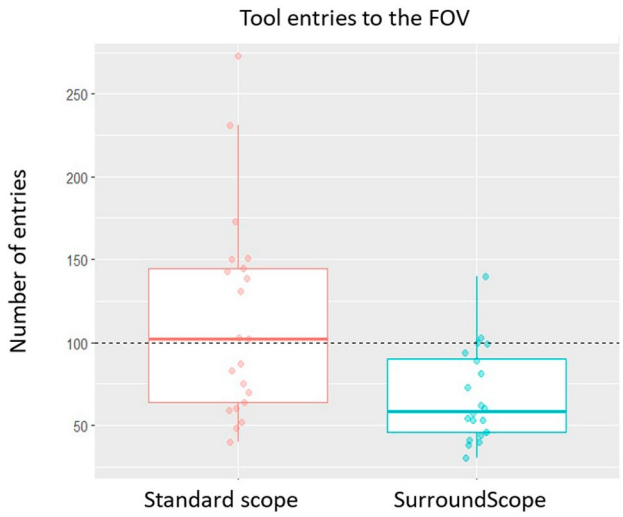

Fig. 2 Number of entries to the FOV with the SurroundScope vs. the standard scop

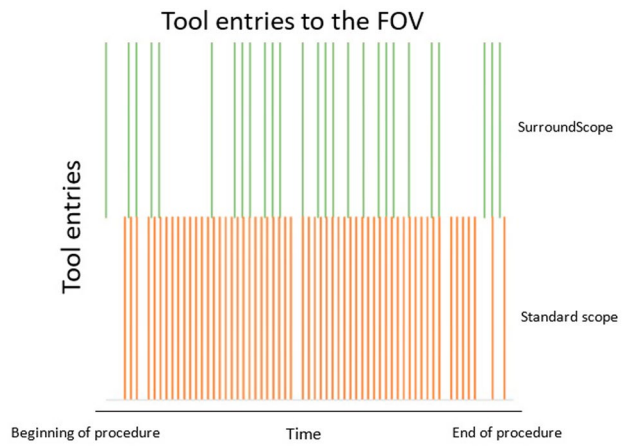

Fig. 3 Entry of tools to FOV during two cholecystectomies performed with the SurroundScope vs. the standard scope

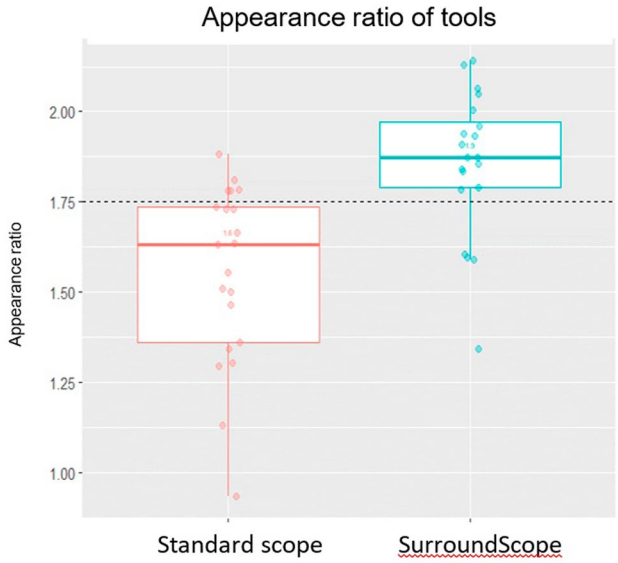

Fig. 4 Appearance ratio of tools in the FOV with the SurroundScope vs. the standard scope

The usage of SurroundScope resulted in a significantly higher appearance ratio of tools, with a value of 1.87 compared to 1.63 for standard scope (*P*-value < 0.0001). This indicates that tools were 20% more likely to appear in the field of view when using SurroundScope (Fig. 4).

When using the SurroundScope, the appearance ratio of ports was significantly higher, measuring 1.84 compared to 0.27 for the standard scope (*P*-value < 0.0001). This indicates that the presence of ports in the field of view was 5 times greater when using SurroundScope compared to the standard scope (Fig. 5).

Among the cholecystectomies performed with SurroundScope, the scope had to be removed and reinserted due to smoke or fog in only 2 cases (9.5%) (in the beginning of the procedure due to very low room temperature), compared to 12 cases (57.1%) in the standard scope group (*P*-value < 0.01), as shown in Table 2.

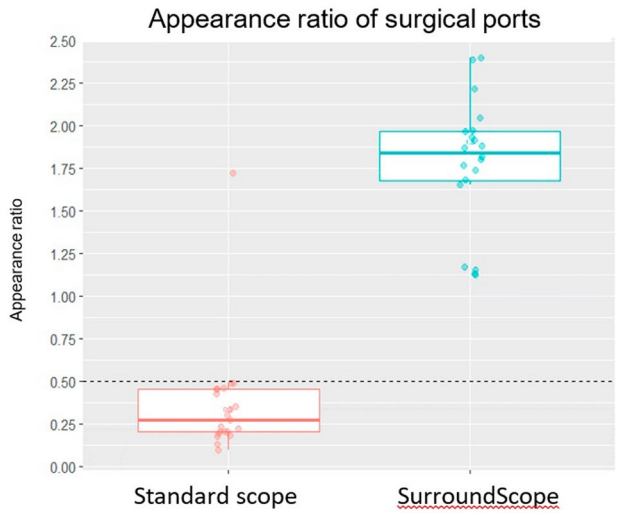

Fig. 5 Appearance ratio of tools in the FOV with the SurroundScope vs. the standard scope

Discussion

Our study shows an increased ports and tools exposure time, a reduction of sudden tool appearances in the FOV and a reductions of scope removals due to fog and smoke.

Factors effecting surgical workflow have been studied extensively [8–16]. Terms used in the literature to describe these factors have included annoyances, distractions, interruptions and disturbances, and some have even suggested to index these terms [12, 15]. However, it seems that there is no consensus on the use of these terms and their definition.

In this study, we refer to appearances in the FOV as interruptions, which have the potential to distract the surgeon's attention while performing the main surgical task. We refer to occurrences that necessitate pausing the operation, such as scope removal due to fog or smoke as a disruption.

Recently, a systematic review [6] estimated that on average, about 20.5% of operating time was attributed to flow disruptions (FDs). They reported the first summary statistics for the prolongation of surgery time associated with FDs. Even though it couldn't determine the actual prolongation of surgeries caused by FDs, it seems that procedures with low levels of disruptions tend to be shorter. They also noted that longer operating times meant longer working hours for the OR team, longer anesthesia for the patient and higher costs for the hospital and should therefore be kept to a minimum.

Additionally, distracting conditions in OR, including visual distractions, were demonstrated to have an impact on surgical errors compared to non-distracting conditions [17] ($z = -2.255$; $P = 0.02$).

The definitions of the FDs in previous publications have included factors internal and external to the operative field, as well as the relationship between them [11, 17]. Although many factors related to surgical workflow have been studied, our study is unique in examining factors relates to the camera technology used. Our study clearly shows a significantly smaller number of events that can be referred to as interruptions to the FOV which may distract the surgeon from the main surgical task, potentially having a negative effect on surgical workflow and patients' safety.

Disruptions due to fog and smoke during laparoscopy are well known [18–20], resulting in the need to pause, clean, reinsert and reposition the camera. Fog and smoke disruptions are particularly relevant in gallbladder operations since the need to coagulate the gallbladder bed in the liver is very common. Our study quantifies disruptions to the surgical flow that are attributed to this technological limitation.

Additionally, our study is the first to report and quantify interruptions to the surgical flow that are attributed to the main laparoscopic limitation, i.e., the limited FOV.

We have shown that enabling a much wider FOV maintains a constant view of the surgical tools, thus dramatically decreases the interruptions caused by sudden appearances of tools in the FOV. Such interruptions might require the surgeon to refocus his or her attention repetitively, sometimes without his or her awareness.

The limited FOV represents mismatches between the work demands and the configuration of the system to support the work. It enforces the need to frequently move the camera towards the working area and having the assistant to lead it in a perfect harmony with the surgeon tasks. Such movements can be for trocar placement, guiding surgical tools from the port to the target site, adhesiolysis, locating lost gallbladder stone or gauze, watching the needle while suturing or removing resected tissue through the port, etc.

The SurroundScope provides a much higher tools and ports exposure time during the laparoscopic procedure. The more tools and ports exposure time, the less camera movements are needed and less dangerous non-viewed tool movements occur.

The wide FOV and the reduced need to pause the procedure due to fog and smoke enables a reduction in FDs, thus optimizing surgical workflow, with the potential of increasing safety and reducing intraoperative costs.

Conclusions

Limitations of standard scope technology effect surgical workflow. For the first time, this study provides a quantified assessment these limitation, while comparing the standard technology to a novel, wide FOV SurroundScope.

The SurroundScope's ability to offer a wider FOV and the improved technology that addresses fog and smoke, can minimize procedural limitations for the surgeon and streamline the surgical workflow.

Further studies should be conducted to examine the potential benefit of this technology in terms of safety and cost.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00464-023-10230-7.

Funding This study was funded by 270Surgical Ltd., Natanya, Israel.

Declarations

Disclosures Shirley S. Shapira is an employee at 270Surgical Ltd. and owns employee stock options in 270Surgical Ltd. Zvi Ehrlich and Gideon Sroka have no conflicts of interest or financial ties to disclose.

References

1. Buia A, Stockhausen F, Hanisch E (2015) Laparoscopic surgery: a qualified systematic review. World J Methodol 5(4):238–254
2. Esposito C, St Peter SD, Escolino M, Juang D, Settimi A, Holcomb GW (2014) Laparoscopic versus open inguinal hernia repair in pediatric patients: a systematic review. J Laparoendosc Adv Surg Tech 24(11):811–818
3. Kasai M, Cipriani F, Gayet B, Aldrighetti L, Ratti F, Sarmiento JM et al (2018) Laparoscopic versus open major hepatectomy: a systematic review and meta-analysis of individual patient data. Surgery 163(5):985–995
4. Hajibandeh S, Hajibandeh S, Gumber AO, Wong CS (2016) Laparoscopy versus laparotomy for the management of penetrating abdominal trauma: a systematic review and meta-analysis. Int J Surg 34:127–136
5. Hassler KR, Collins JT, Philip K, Jones MW (2023) Laparoscopic cholecystectomy. StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK448145/ Accessed 30 May 2023
6. Koch A, Burns J, Catchpole K, Weigl M (2020) Associations of workflow disruptions in the operating room with surgical outcomes: a systematic review and narrative synthesis. BMJ Qual Saf 29(12):1033–1045
7. Thompson KJ, Sroka G, Loveitt AP, Matter I, McCollister HM, Laniado M et al (2022) The introduction of wide-angle 270° laparoscopy through a novel laparoscopic camera system. Surg Endosc 36(3):2151–2158
8. Al-Hakim L (2011) The impact of preventable disruption on the operative time for minimally invasive surgery. Surg Endosc 25(10):3385–3392
9. Persoon MC, Broos HJHP, Witjes JA, Hendrikx AJM, Scherpbier AJJM (2011) The effect of distractions in the operating room during endourological procedures. Surg Endosc 25(2):437–443
10. Arora S, Sevdalis N (2010) Surgical flow disruptions: measurement and impact of stressful events in the operating room. World J Surg 34:2247–2248
11. Al-Hakim L, Xiao J, Sengupta S (2017) Ergonomics perspective for identifying and reducing internal operative flow disruption for laparoscopic urological surgery. Surg Endosc 31(12):5043–5056
12. Healey AN, Primus CP, Koutantji M (2007) Quantifying distraction and interruption in urological surgery. Qual Saf Health Care 16(2):135–139
13. Al-Hakim L (2011) Surgical flow disruption: measurement and impact of stressful events in the operating room. World J Surg 35:929–930
14. Wiegmann DA, ElBardissi AW, Dearani JA, Daly RC, Sundt TM (2007) Disruptions in surgical flow and their relationship to surgical errors: an exploratory investigation. Surgery 142(5):658–665
15. Sevdalis N, Forrest D, Undre S, Darzi A, Vincent C (2008) Annoyances, disruptions, and interruptions in surgery: the Disruptions in Surgery Index (DiSI). World J Surg 32(8):1643–1650
16. Zheng B, Martinec DV, Cassera MA, Swanström LL (2008) A quantitative study of disruption in the operating room during laparoscopic antireflux surgery. Surg Endosc Other Interv Tech 22(10):2171–2177
17. Pluyter JR, Buzink SN, Rutkowski AF, Jakimowicz JJ (2010) Do absorption and realistic distraction influence performance of component task surgical procedure? Surg Endosc 24(4):902–907
18. Lawrentschuk N, Fleshner NE, Bolton DM (2010) Laparoscopic lens fogging: a review of etiology and methods to maintain a clear visual field. J Endourol 24(6):905–913
19. Song T, Lee DH (2020) A randomized Comparison of laparoscopic LEns defogging using Anti-fog solution, waRm saline, and chlorhexidine solution (CLEAR). Surg Endosc 34(2):940–945
20. Manning TG, Perera M, Christidis D, Kinnear N, McGrath S, O'Beirne R et al (2017) Visual occlusion during minimally invasive surgery: a contemporary review of methods to reduce laparoscopic and robotic lens fogging and other sources of optical loss. J Endourol 31(4):327–333

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.