European Journal of Trauma and Emergency Surgery
https://doi.org/10.1007/s00068-020-01413-1

ORIGINAL ARTICLE

Enhancing safety of laparoscopic surgery in COVID-19 era: clinical experience with low-cost filtration devices

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Received: 24 April 2020 / Accepted: 29 May 2020

Abstract

Background Surgery in the era of the current COVID-19 pandemic has been curtailed and restricted to emergency and certain oncological indications, and requires special attention concerning the safety of patients and health care personnel. Desufflation during or after laparoscopic surgery has been reported to entail a potential risk of contamination from 2019-nCoV through the aerosol generated during dissection and/or use of energy-driven devices. In order to protect the operating room staff, it is vital to filter the released aerosol.

Methods The assemblage of two easily available and low-cost filter systems to prevent potential dissemination of Coronavirus via the aerosol is described.

Results Forty-nine patients underwent laparoscopic surgeries with the use of one of the two described tools, both of which proved to be effective in smoke evacuation, without affecting laparoscopic visualization.

Conclusion The proposed systems are cost-effective, easily assembled and reproducible, and provide complete viral filtration during intra- and postoperative release of CO_2.

Keywords Coronavirus · Laparoscopy · Emergency surgery · Oncologic surgery · Prevention · Pneumoperitoneum

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Published online: 01 June 2020

Introduction

The COVID-19 outbreak is dramatically impacting health care systems and personnel worldwide. Surgical activities are affected because of recommendations to cancel elective surgery, surgeons being shifted to other medical activities, the need to set up specific pathways and theaters for COVID-19 positive and/or suspected patients, redesigning of time-dependent networks of care (stroke, cardiovascular accidents, trauma), as well as changes in pre- and post-operative care [1–4].

Notwithstanding, indications for surgical management of emergencies and oncological scenarios remain. Many of these procedures are performed laparoscopically because of the well-established advantages [5]. However, learned societies have published words of caution with regard to the use of laparoscopic surgery during the current COVID-19 pandemic [6], and therefore concerns have risen in view of the previous studies demonstrating the presence of HIV, Papillomavirus and Corynebacterium in surgical smoke [7–9]. While there is no formal proof that aerosols of the novel Coronavirus (2019-nCoV) created during laparoscopic procedures can be dangerous, protective measures for patients and surgical teams are warranted [1–6, 10–15]. Desufflation, whether during or at the end of the operation or during specimen retrieval or conversion to open surgery calls for particular attention. Recommendations to ensure a perfectly hermetic peritoneal cavity during surgery [5] and a closed evacuation system with adequate filtering device have been proposed [16]. The aim of this paper is to describe the feasibility and efficacy of the systems we used in our units during laparoscopic surgery during the last few weeks of the current COVID-19 pandemic.

Methods

Two systems including the same type of filter were developed: the first made use of a male-to-male connector (male-2-male LL, Vygon, Ecouen, France), a 25-cm long Luer-lock infusion connector (BD Connecta™, Becton Dickinson, Sweden), an electrostatic filter HME (Heat and Moisture Exchanger) (DAR™, Covidien, Mansfield, MA, USA) with end tidal CO_2 port, and a 15-mm cap for fenestrated inner tracheostomy cannula (Shiley™, Covidien, Boulder, CO, USA) (Fig. 1a–c). The second, a similar device with the same principles consisted of a rubber/Luer-lock connector (AK3100 ref., Coloplast-Porgès™, Denmark), commonly used for infusion of fluids or connecting drainages; a blue connector included in the Rüsch™ Breathing kit for ventilators (ref. 191565-201800, Teleflex Medical, Dublin, Ireland), and the same electrostatic filter HME (DAR™, Covidien, Mansfield, MA, USA) (Fig. 2a–c). The key object

Fig. 1 **a** Material required for the filtering system I; **b** system I assembled; **c** system I in clinical use

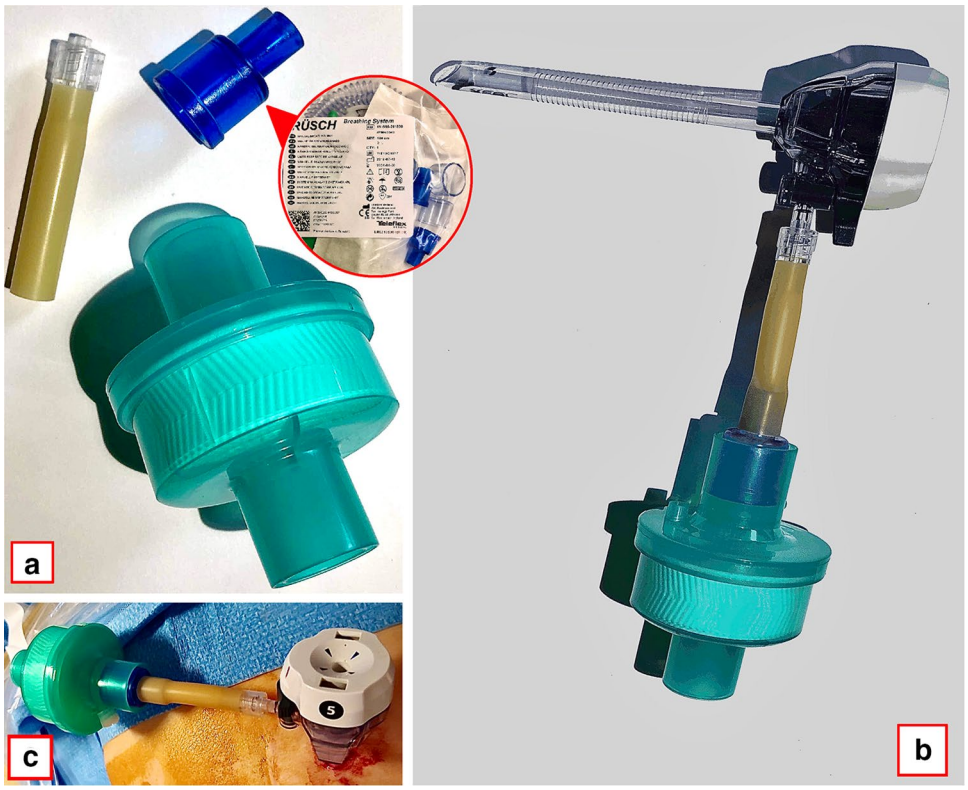

Fig. 2 **a** Material required for the filtering system II; **b** system II assembled; **c** system II in clinical use

of these constructions is the filter. HME filters have high resistance to flow and, most important, a bacterial and viral filtration efficiency of ≥ 99.999%.

The filter system can be connected to one or more trocars (Figs. 1b, c, 2b, c). In order to prevent inadvertent release of gas from a non-filtered trocar, a cap is applied over all other ports. Decompression at the end of surgery can be enhanced with a conventional suction device introduced into one of the trocar shafts. During gas evacuation, the tip of the suction device should remain in the trocar shaft in order not to draw tissues inside. The systematic use of disposable trocars should guarantee maximal effectiveness of the valves and avoid the risk of diffusion during of instrument exchange.

Specimen extraction was performed at the end of the procedures, preceded by complete desufflation of pneumoperitoneum through the filtered trocar. All OR staff adopted standard PPE according to WHO and local institutional protocols. Systems were both approved by the IRB of the Department of Surgery, Medical University of Graz.

The average cost for both systems is approximately $ 10.

Results

The systems were initially tested on three COVID-19 positive patients undergoing laparoscopic appendectomy, laparoscopic adhesiolysis for single band small bowel obstruction and laparoscopic colonic resection for retroperitoneal diverticular perforation and abscess, respectively. The first system was sufficient for both appendectomy and adhesiolysis. The second system was employed for the patient with colonic resection. To date, both devices were routinely used in 49 abdominal procedures including a gastrectomy, right and left colectomies, small bowel obstructions, appendectomies and cholecystectomies in the hospitals of the authors in Italy and Austria (Table 1). 8patients were tested as positive before the operation; 9 out of the remaining 41 showed positive tests in the postoperative period. In all but two operations, only one trocar was equipped with the filtering device. Both systems were thought to be effective in all patients. To date, none of the personnel in either of the operating room staffs has been reported to be ill, or tested positive for COVID-19.

Table 1 Use of filtering systems in laparoscopic surgery

Use of filtering systems in laparoscopic surgery (no. 49)			
Procedure	No.	System I	System II
Appendectomy	15	10	5
Cholecystectomy	21	16	5
Small bowel obstruction	3	2	1
Colonic resection	9	2	7
Gastrectomy	1		1

Discussion

Our study shows, as others [16], that it is possible to avoid dispersion of potentially virus-bearing aerosol into the ambient air of operating rooms by use of a simple, easily assembled, cost-effective and readily available filter system.

At present, there are no data that prove 2019-nCov can be transmitted to operating room personnel when the pneumoperitoneum is released at the end of the operation, or inadvertently during exchange of instruments, dislocation of ports, or before specimen retrieval. Likewise, no data are available about the presence of 2019-nCoV in peritoneal fluid.

There is increasing evidence that 2019-nCoV is present in stool [17]. Around 2–10% of patients with COVID-19 have gastrointestinal symptoms such as diarrhea, abdominal pain, and vomiting [18].

For these reasons, COVID-19 positive or suspected patients needing emergency surgery entailing perforation or intentional opening of the intestinal tract (oncological procedures) should be considered as a potential source for virus dissemination.

The main concern, however, is to eliminate any possible contamination in the CO_2 used for creation of pneumoperitoneum. One very recent paper indicated that 2019-nCoV remains viable in aerosols for at least 3 h and on surfaces up to 2 or 3 days [19]. However, whether these experimental results in a Goldberg drum are reproducible for laparoscopic surgery in the human remains to be shown, and the conclusions of the authors are cautious "… aerosol and fomite transmission of SARS-CoV-2 is plausible". Should this be the case, the HME filters have a bacterial and viral filtration efficiency of $\geq 99.999\%$ [20]. Including such easily assembled filtering systems as described above can offer a complete viral filtration during intra- and postoperative release of pneumoperitoneum.

Of note, the length of the connection to the filter could affect the efficiency. For this reason, we strove to find the shortest connectors available in both systems. Our first system, although similar to the recently described EAES system [16], was developed independently, but used slightly shorter connectors. Our second system was developed with the intention to overcome the relatively slow rate of smoke evacuation of the first, in particular for operations requiring extensive dissection and prolonged use of cautery and/or energy devices and uses connecting tubes that are shorter and, above all, larger than the first.

For mechanical reasons, the use of the second system was effectively felt to improve operative field visibility quickly and thus shorten overall operation duration. Likewise, high volumes of smoke/aerosolized tissue, as generated during lengthy operations, are managed adequately.

In order to obtain a systematic use and the standardization of the procedure, we suggest to prepare dedicated kits, ready for use. This strategy has been easily accepted by the OR staff of our hospitals, with a high degree of compliance. Finally, the use of these systems should increase the awareness of the entire OR staff about the problem of surgical plumes and their diffusion.

Additional preventive measures are of interest.

Low pressure pneumoperitoneum (LPP) [1–3, 5, 10–12] might reduce uncontrolled exit of aerosol during the change of instruments. LPP should also reduce the pressure on the diaphragm, especially important in patients with compromised respiratory function [5]. We, as others [5, 11–15, 21], strongly recommend to reduce the intensity and duration of use of energy devices with increased smoke production, careful insertion/extraction of the instruments, and accurate use of aspiration devices during laparoscopic procedures. Likewise, we recommend to oversee that a perfect orthogonal axis of instruments during insertion is maintained, minimizing the risk of inadvertent escape of CO_2 through the trocar shaft valve.

Conclusion

The proposed equipment is a cost-effective solution to address the concerns related to the potential infection risk for the OR personnel due to laparoscopic aerosol, while enhancing the visibility of surgical field during laparoscopic surgery; we recommend that they be used routinely in all COVID-19 positive or potentially positive patients undergoing laparoscopic surgery.

Author contributions MZ, SU, MEC, SG, LAF, MT, MC, DM, VW, HK, AF made substantial contributions to conception and design, acquisition of data, and analysis of the potential effectiveness of the proposed device. All authors participated in drafting the article and revising it critically, contributing with relevant scientific knowledge. All authors gave final approval of the version to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The particularity of the experience justifies the number of authors.

Funding None.

Compliance with ethical standards

Conflict of interest All the authors declare that they have no conflict of interest.

Ethics approval and consent to participate Not applicable; in accordance with the Declaration of Helsinki.

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