AEROSOL MANAGEMENT DURING THE COVID-19 PANDEMIC

Manejo de aerossóis durante a pandemia da COVID-19

Manejo de aerosol durante la pandemia COVID-19

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ABSTRACT: Objective: To describe the prototyping process of a filtration device for aerosol management in laparoscopic procedures during the SARS-CoV-2 coronavirus pandemic. **Method**: Descriptive study with the report of experience on the prototype filter device for aerosol management in laparoscopy during the SARS-CoV-2 COVID-19 pandemic, based on immersion, ideation and design thinking prototyping processes. **Results**: Preliminary and deep immersion processes allowed the problem to be addressed. The use of a mental map helped to identify factors related to surgery suspensions due to the SARS-CoV-2. Based on the measurements of the operating room aspirator, the necessary material resources were idealized: suction extender, bacteriological and viral filter, connector and tip. **Conclusion**: The device for filtering carbon dioxide from the pneumoperitoneum was well accepted by the surgical team and incorporated into the sector's routine for laparoscopic surgeries.

Keywords: Betacoronavirus. Laparoscopy. Pneumoperitoneum, artificial. Equipment and supplies. Surgery department, hospital.

RESUMO: Objetivo: Descrever o processo de prototipação de um dispositivo de filtragem para manejo de aerossóis em procedimentos laparoscópicos durante a pandemia do coronavírus SARS-CoV-2. **Método:** Estudo descritivo, tipo relato de experiência sobre o protótipo de dispositivo de filtragem para manejo de aerossóis em laparoscopia durante a pandemia de COVID-19 pelo SARS-CoV-2, com base nos processos de imersão, ideação e prototipação do *design thinking*. **Resultados:** Os processos de imersão preliminar e profunda permitiram a abordagem do problema. A utilização do mapa mental proporcionou a identificação dos fatores relacionados às suspensões de cirurgias em decorrência do SARS-CoV-2. Pelas medidas do aspirador das salas cirúrgicas, idealizaram-se os recursos materiais necessários: extensor de aspiração, filtro bacteriológico e viral, conector e ponteira. **Conclusão:** O dispositivo para filtragem do dióxido de carbono do pneumoperitônio obteve boa aceitação da equipe cirúrgica e foi incorporado à rotina do setor durante a realização de cirurgias laparoscópicas.

Palavras-chave: Betacoronavírus. Laparoscopia. Pneumoperitônio artificial. Equipamentos e provisões. Centro cirúrgico hospitalar.

RESUMEN: Objetivo: Describir el proceso de prototipado de un dispositivo de filtración para el manejo de aerosol en procedimientos laparoscópicos durante la pandemia de Coronavirus SARS-CoV-2. **Método:** Estudio descriptivo, un relato de experiencia sobre el prototipo de dispositivo de filtrado para el manejo de aerosol en laparoscopia durante la pandemia de COVID-19 por SARS-CoV-2, a partir de los procesos de inmersión, ideación y prototipado del *Design Thinking*. **Resultados:** Los procesos de inmersión profunda y preliminar permitieron abordar el problema. El uso del Mapa Mental permitió identificar los factores relacionados con la suspensión de cirugías debido al SARS-CoV-2. A partir de las mediciones del aspirador de las salas quirúrgicas, se idearon los recursos materiales necesarios: extensor de aspiración, filtro bacteriológico y viral, conector y férula. **Conclusión:** El dispositivo para filtrar dióxido de carbono del neumoperitoneo obtuvo buena aceptación por parte del equipo quirúrgico y fue incorporado a la rutina del sector durante las cirugías laparoscópicas.

Palavras clave: Betacoronavirus. Laparoscopía. Neumoperitoneo artificial. Equipos y suministros. Servicio de cirugía en hospital.

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INTRODUCTION

In December 2019, physician Li Wenliang warned about the first cases of a pneumonia of unknown etiology in Wuhan, Hubei Province, China. Most of the infected people worked or lived close to the local seafood market, where live animals were also sold[1,2].

One month later, the Chinese Centers for Disease Control and Prevention identified the coronavirus 2 (SARS-CoV-2) in a swab sample taken from a patient with the severe acute respiratory syndrome. A new coronavirus with considerably higher morbidity and mortality than other viruses belonging to the same family, such as the SARS-CoV and the Middle East respiratory syndrome coronavirus (Mers-CoV)[3].

Thus, the so-called coronavirus disease 2019 (COVID-19) emerged, a disease caused by the SARS-CoV-2, characterized by mild symptoms such as flu-like illness, and good prognosis in most patients, but with the possibility of severe acute respiratory infection symptoms, with rapid development to an acute respiratory distress syndrome, acute respiratory failure, severe pneumonia, pulmonary edema, multiple organ failure, other serious complications, and death[2].

In Brazil, the first confirmed case of COVID-19 was identified on February 26, 2020. The patient was an elderly man, resident in the city of São Paulo (SP), who had recently returned from a trip to Italy. On March 17, 2020, the first death was registered in the country: also a male elderly resident in São Paulo, who had diabetes and hypertension, but no history of traveling abroad[4]. In the same month, the SARS-CoV-2 pandemic was officially declared and governments around the world began to implement strategies to try and slow the spread of the virus[2].

Considering the growing number of confirmed cases in Brazil, with a total of 3,997,865 cases almost five months after the first notification, being 3,210,405 recovered patients and 123,780 deaths[5], health authorities recommended the rescheduling of elective surgical procedures under the justification of providing beds and mechanical ventilation equipment for critically ill patients and the increased local demand[6].

During the pandemic, urgent and emergency surgeries were advised to be performed through an action plan, in which the entire multidisciplinary team was guided on how to proceed effectively and using personal protective equipment (PPE), as well as allowing a minimum number of people in the operating room (OR) to avoid the contamination of professionals[6].

The laparoscopic surgery has become increasingly frequent in health services[7]. It is a minimally invasive surgical technique that aims to reduce the length of stay of patients, reduce postoperative pain and provide comfort in the postoperative period and better aesthetic results compared to the conventional surgical technique[8].

In laparoscopic surgeries, carbon dioxide (CO_2) is used to expand the abdomen. This space constitutes the pneumoperitoneum, in which the insufflation of gas is usually made in the umbilical scar by a Veress needle, allowing the surgeon to handle surgical instruments for the procedure. In the end, the abdominal cavity is emptied, that is, CO_2 is eliminated[9].

Considering the SARS-CoV-2 pandemic, experts recommend using ultrafiltration systems during gas removal and avoiding sudden emptying of the pneumoperitoneum, emphasizing that the incisions for the passage of surgical instruments should be performed in the smallest possible diameter, decreasing the possibility of leakage. Such concerns are pertinent, as they relate to the risk of aerosolization of SARS-CoV-2 in the environment and the risk of contamination of health professionals involved[10].

In laparoscopic surgeries, the procedure must be performed by the most experienced surgeon, with special care during the introduction and removal of trocars, while checking valves and sealing rubbers, reducing the number of puncture sites and using filtering mechanisms during inflation and deflation of the pneumoperitoneum, thus allowing for a lower possibility of CO_2 dispersion into the surgical environment[11] and exposure of professionals to the coronavirus.

The guidelines of use of filtering systems for the evacuation of the pneumoperitoneum guided the problematization of this study. In the absence of this resource in a hospital, how to ensure safe laparoscopic surgical procedures while avoiding the dispersion of contaminating aerosols?

OBJECTIVE

To describe the prototyping process of a filtration device for aerosol management in laparoscopic procedures during the SARS-CoV-2 COVID-19 pandemic.

METHOD

This is a descriptive study, experience report type, on the prototyping process of a filtering device for laparoscopic

procedures, based on design thinking[12] and on the professional experience of nurses from surgical centers, working in the area for over 10 years.

The setting of this study was the surgical center of a public hospital in the state of Rio de Janeiro, with seven operating rooms (ORs), used by urology, gynecology, vascular, proctology, pediatrics and general surgery clinics. The research was carried out during May and June of 2020, period of the first wave of contamination by SARS-CoV-2 in Brazil.

Design thinking, the guiding axis for this research, is defined as a creative methodology for the development of innovative products, an approach focused on identifying problems and building solutions based on immersion, ideation and prototyping processes[12,13].

The first phase was immersion, in which the needs are identified in an exploratory way to analyze the context of a problem and establish an initial understanding, proceeded in two stages: preliminary immersion and in-depth immersion[12].

In the preliminary immersion, strategic alignment discussions were held with an interdisciplinary team on the necessary adjustments to the return of elective surgeries, until then suspended due to restrictive measures to contain the advance of contamination by the coronavirus, for the reframing process.

Anchored in the concept of desk research, a vast search for information on the subject[12] was carried out, with a theoretical deepening related to laparoscopic surgical procedures and safe evacuation of CO_2 from the pneumoperitoneum in the intraoperative period.

The in-depth immersion began with the elaboration of an observational plan to map the settings to be considered for product development and problem solving. Then we had the observation in the operating field, with reflections and screenings by surgery-specializing nurses, regarding the steps that involved the supply, propagation and elimination of CO_2 during laparoscopic procedures.

The immersion the field, with an eye on mapping the needs of direct users of technology (surgeons and patients) and indirect users (other members of the interdisciplinary team of the operating room) allowed the designing of the product's requirements, the process of use, and the mitigation of the problem of environment contamination and, perhaps, infection of workers by the CO_2 eliminated from the abdominal cavity of a patient with SARS-CoV-2.

After surveying the data in the immersion phase, the analysis and synthesis were carried out through the construction of a mind map, in the free web application GoConqr[14], a visual representation with words, images and colors for information and knowledge management as a tool for understanding and solving problems[15].

Afterwards, the ideation process was instituted based on immersion and the mental map, all in compliance with guidelines[10] for the return of elective surgeries during the SARS-CoV-2 pandemic, review of the surgical-laparoscopic care process, assessment of feasibility, safety and usability of the technology, as well as justification for its implementation.

The device's prototyping, which consists of transforming the abstract idea into a physical product, was made in a way it could represent the reality and allow validations[12] and took place in the study setting. After two phases of adjustments, the final prototype for filtering CO_2 from the pneumoperitoneum was chosen. The device was tested and evaluated by surgeons and nursing professionals, who received prior training on its purpose and on the handling and installation techniques.

RESULTS

The preliminary and deep immersion processes allowed addressing the target problem of this study: the need for a device to filter CO_2 from the pneumoperitoneum of patients undergoing laparoscopic surgery during the SARS-CoV-2 pandemic, according to current guidelines.

Based on literature mainly related to surgical activities, based on desk research, interdisciplinary discussions, observation of the surgical environment, description of surgical care, infrastructure, worker health and patient safety, the analysis process to build solutions was initiated.

The mental map helped to identify factors related to the suspension of surgeries due to SARS-CoV-2 in line with patients, health professionals and infrastructure, synthesis, planning and structuring of thought, exploration of ideas while keeping the focus on the need for a CO_2 filtration system, as shown in Figure 1.

After tracking the primordialities and mapping the spaces of care, an ideation report was prepared with a justification for implementation and inputs available in the institution to prototype the device, object of this study.

Based on the measurements of ORs' aspirators, the product was idealized: an aspiration extender and a bacteriological and viral filter (Figure 2).

Due to the incompatibility of the diameters, a connector and a tip were used as adapter (Figure 3).

Figure 4 shows the idealization of the prototype of the CO^2 filter for the pneumoperitoneum and connection to the trocar.

Figure 5 shows the device for filtering CO_2 coupled to a portable vacuum and a wall vacuum.

The device was presented to the surgical medical and nursing teams, including the elements that compose it, in order to provide information to implement and disseminate the concept.

DISCUSSION

The methodology applied through the processes of immersion, ideation and design thinking prototyping, associated with the elaboration of a mental map, allowed us to achieve the objective of this study.

Creativity was used as a resolving measure, considering the negative impacts on the physical and emotional health of patients resulting from the increased wait to perform a surgical procedure, the need to protect professionals and the work environment, minimizing the risk of contamination and the difficulty in acquiring supplies/equipment in the public health service.

The prototype was incorporated into the sector's routine of videolaparoscopic surgeries using CO_2. The use of filters in laparoscopic surgeries is ratified, emphasizing that adaptations and associations are necessary for the prevention and protection of the risk of infection of health professionals in the context of SARS-CoV-2[16].

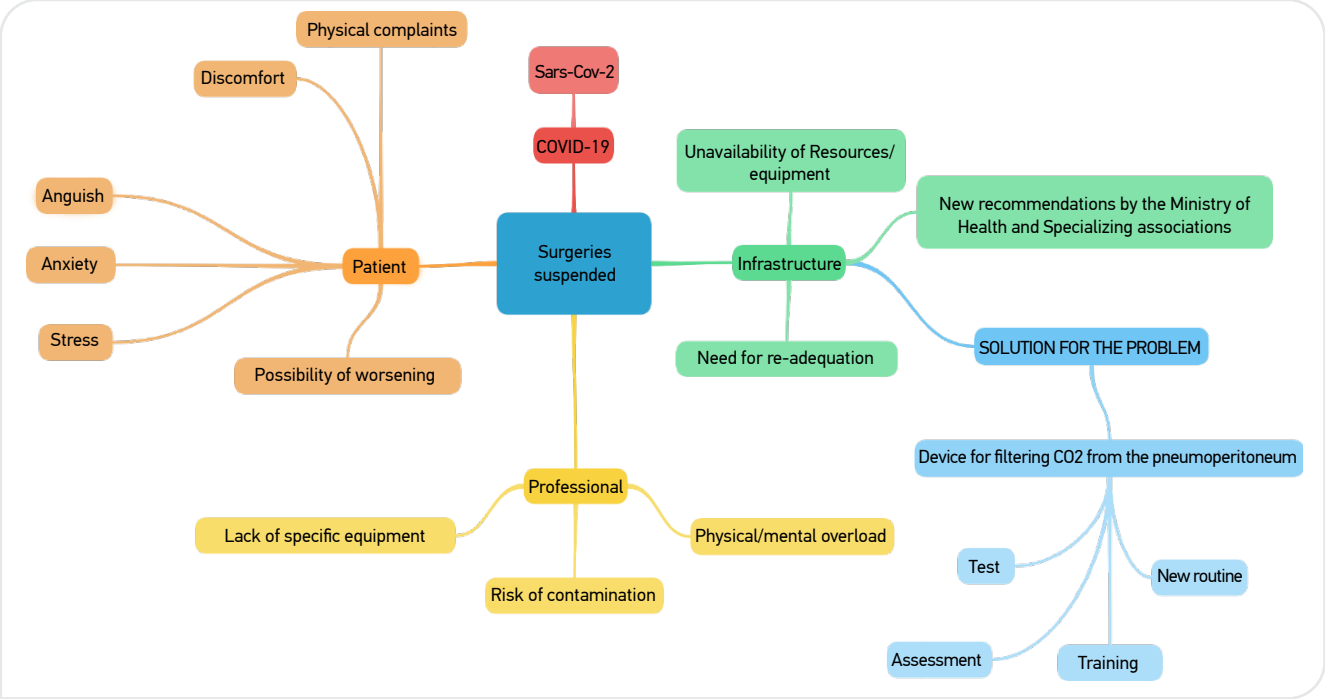

Figure 1. Mental map of aspects related to the suspension of surgeries.

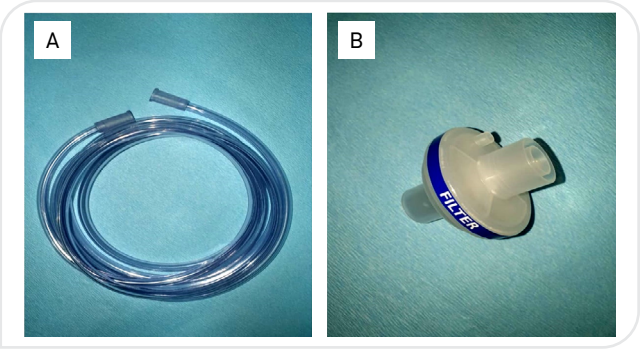

Figure 2. (A) Suction extensor and (B) bacteriological and viral filter.

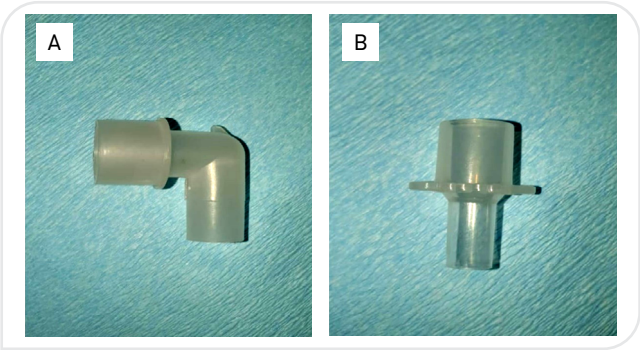

Figure 3. Connector and tip.

Caution is recommended in the management of pneumoperitoneum during laparoscopic procedures, for both insufflation and deflation, due to dispersing aerosols in the room. Given the potential risk of contamination, the association of PPE with a pneumoperitoneum filtering barrier is cited as prevention against SARS-CoV-2. The use of filtering devices coupled to an extender is suggested, so the surgical team can keep a distance of at least two meters from the patient as a safety measure[11,17].

Another study reported a device prototyping with materials that are easy to purchase in the hospital environment, due to the unavailability of filtering devices in the market either due to high demand or to lower financial potential from health institutions or government agencies[18].

The initial surgical procedures using the CO_2 filtering prototype were monitored by one of the authors, who was responsible for setting up with the nursing team assigned to the OR and for providing guidance to surgical instrumentators and surgeons in the preoperative phase. Later on, after training nurses, circulators and surgical instrumentators in the study setting, the prototype was incorporated into the sector's routine for laparoscopic surgeries. It is noteworthy that no leaks, handling difficulties and disconnections during surgical procedures were identified.

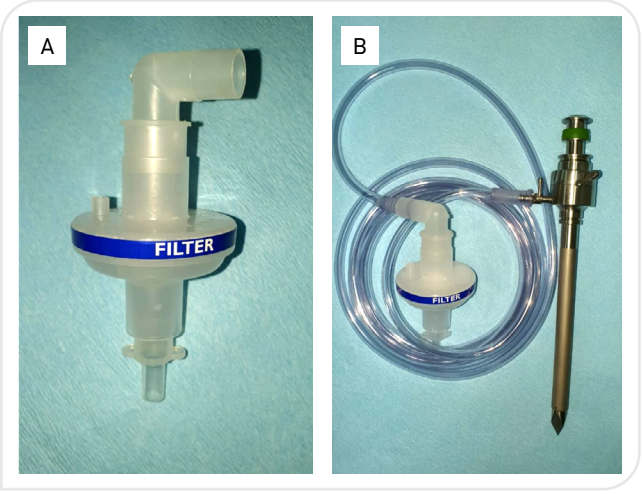

Figure 4. Prototype for filtering CO_2 from the pneumoperitoneum and connecting to the trocar.

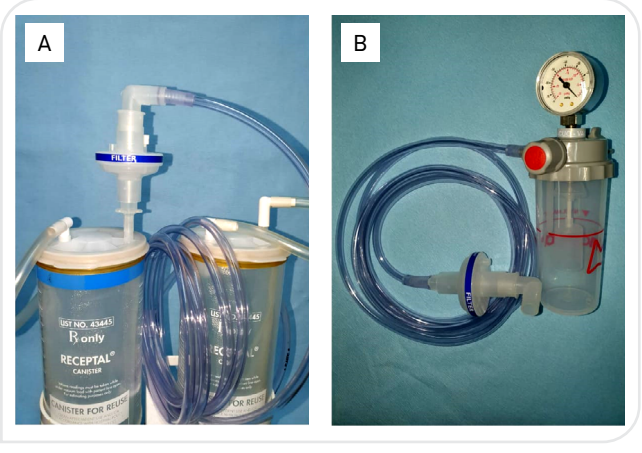

Figure 5. Device for filtering CO_2 coupled to a portable vacuum and a wall vacuum.

The health team involved in the surgical process had good acceptance. This is believed to be related to the ease of its composition with materials already known by professionals. As this was the prototype of an unfunded and emergency device for the maintenance of the surgical service, patient care and worker safety, inputs available in the hospital material grid were used and added with creative reasoning[13] and the authors' expertise.

In the case of surgical procedures, it is advisable to carefully evaluate the possibility of conservative treatment[16] and/or postponement of surgeries.[17] However, in some cases, the surgical approach becomes essential, impacting the functioning routine of the surgical center, which has an exclusive area for patients with suspected or diagnosed SARS-CoV-2[17,18].

The SARS-CoV-2 pandemic made the implementation of new care protocols mandatory, based on scientific evidence and development of professional skills, which include remodeling and replacement of supplies for the maintenance of essential health care, such as laparoscopic surgical procedures. The implementation of institutional guidelines and the adequacy of surgical practices to care for patients with suspected or confirmed SARS-CoV-2 infection is emphasized, in order to minimize the exposure of health professionals and other patients to the virus[17,19].

A limitation of this study was the clinical validation, the last step for the expansion of knowledge and reliability of the pneumoperitoneum CO_2 filtering device as an effective resource to prevent the dispersion of aerosols into the environment.

CONCLUSION

We concluded that the design thinking processes and the integration of the knowledge of nurses from surgical centers allowed the development of a prototype to manage aerosols in videolaparoscopic procedures, taking into account the

technical recommendations on pneumoperitoneum filtering barriers as prevention of SARS-CoV-2.

It is an easy-to-assemble device, whose use has a short learning curve, and consisting of supplies available in the hospital grid, used to provide greater safety for health professionals and patients.

The prototype was included in the routine of the study setting, with good acceptance by the surgical team, being used during videolaparoscopic procedures in patients with suspected or confirmed SARS-CoV-2 infection during the first wave of the pandemic in Brazil.

It is reiterated that the prototyping was necessary because of the unavailability of resources to filtering CO_2 from the pneumoperitoneum and maintenance of surgical care in the institution. However, scientific deepening is needed with regard to clinical validation, to assess the reliability of the device and the continuity of the study.

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