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REVIEW

Risks of viral contamination in healthcare professionals during laparoscopy in the Covid-19 pandemic

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Summary The Covid-19 pandemic has markedly changed our practices. This article analyses the risks of contamination among healthcare professionals (HCPs) during laparoscopic surgery on patients with Covid-19. Harmful effects of aerosols from a pneumoperitoneum, with the virus present, have not yet been quantified. Measures for the protection of HCPs are an extrapolation of those taken during other epidemics. They must still be mandatory to minimise the risk of viral contamination. Protection measures include personal protection equipment for HCPs, adaptation of surgical technique (method for obtaining pneumoperitoneum, filters, preferred intracorporeal anastomosis, precautions during the exsufflation of the pneumoperitoneum), and organisation of the operating room.

Introduction

Contamination of healthcare professionals (HCPs) during surgery has been known for many years and is well described. Before the laparoscopy era, the source was essentially surgical fumes produced by heat-producing techniques such as electrosurgery (mono- or bipolar), lasers or ultrasound [1]. These peroperative risks have been abundantly addressed in the literature, which we need not detail here. Depending on the case, surgical smoke can contain water vapour (95%), inorganic pollutants (CO, CO_2), organic pollutants (hydrocarbons, hydrocyanic acid, aldehydes), and biological pollutants such as cells (some cancerous), bacteria and fragments of viral DNA. Laparoscopy has added a further source of airborne pollution, namely aerosols generated by pneumoperitoneum gas flow. This article specifically concerns the risk of viral contamination during laparoscopy in the setting of the current Covid-9 epidemic. Our purpose here is to analyse the literature data on the viral contamination risk for HCPs by the SARS-CoV-2 coronavirus responsible for the Covid-19 epidemic and discuss means of protection and prevention.

Risk of viral contamination during surgical care

Several viruses have been implicated to different degrees in the contamination of HCPs during surgery: human immunodeficiency virus (HIV), hepatitis B virus (HBV), bovine

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papilloma virus and human papilloma virus (HPV). Most of the studies published on the risk of transmission have used in vitro analyses. Several studies have focused on HPV (during the treatment of warts or condylomas) with cases of laryngeal papillomatosis, recognised as an occupational illness in one nurse [2]. In the 2000s, it was difficult for researchers to measure the biological activity of viral DNA in order to assess its infectiousness [3]. However, viable HIVs have been found in cell cultures, especially when aerosol-generating devices are used, although the viability of HIVs is still being debated, and the potential risk of contamination by smoke has not been quantifiable. [4,5].

For both HPV and HIV, most authors conclude, however, that it is preferable to take all necessary precautions against surgical smoke when operating on infected patients.

There is to our knowledge no large-scale epidemiological study that proves a direct link between a patient's viral load and the contamination of HCPs by emitted surgical smoke. It should also be noted that the published studies have mainly been on surgical smoke from operations on skin or genital lesions. Few studies have evaluated the risk of contamination of HCPs during laparoscopy.

One small-sample study ($n = 11$) analysed the presence of HBV in surgical smoke during conventional and robot-assisted laparoscopies [6]. The aerosol from the pneumoperitoneum was trapped in a filter, where the authors found HBV in 10 instances out of 11. This study thus showed the presence of HBV in pneumoperitoneum gas during surgical laparoscopy. The subject matter of this study comes closest to the issue addressed in this article.

Special features of laparoscopy

Laparoscopic surgery requires the creation and maintenance of an efficient pneumoperitoneum. There is thus a permanent risk of an aerosol effect through gas leaks or at exsufflation. Moreover, the ultrasonic systems often used do not produce enough heat to deactivate the virus. These concerns are confirmed by a recent experimental study showing that after 10 minutes of laparoscopic dissection by electrosurgery or ultrasound, the concentration of particles measuring 0.3—0.5 μm was higher with laparoscopy than with laparotomy [7]. Owing to the low rate of replacement of the pneumoperitoneum gas, leaked aerosol may thus contain high concentrations of suspended viruses [8]. This suggests that the risk of contamination of HCPs may be greater in laparoscopy than in laparotomy, particularly if accidental gas leakage occurs or exsufflation is poorly controlled. Other authors [9] have claimed the opposite, arguing that the closed surgical site (relative to laparotomy) lowers the risk of contamination, and that there is no hard evidence yet that the viruses are viable or that they are actually transmitted during laparoscopy.

All these studies have focused on HIV and HBV and have shown rather low peritoneal contamination. No study to date has considered SARS-CoV-2. Studies have evaluated contamination risk for similar earlier viruses (Middle East coronavirus MERS CoV) but their results cannot be extrapolated to laparoscopy [10]. There is no expert consensus on the actual or extrapolated presence of ambient SARS-CoV-2 in the pneumoperitoneum as factual evidence is lacking [11].

Properties of the SARS-CoV-2 coronavirus

General

The SARS-CoV-2 virus responsible for the Covid-19 pandemic is an RNA virus 0.06—0.14 μm in size. In comparison, the HIV measures 0.12 μm, the HBV measures 0.04 μm, and bacteria about 0.30 μm. The RNA of SARS-CoV-2 is very long (30 kb), making it the largest RNA virus known so far, larger than flu and previous SARS viruses [12]. In infected patients it is found in the oropharynx, the respiratory tract and the whole of the digestive tract. It is not found in urine or cerebrospinal fluid.

Ultrastructure

Like other coronaviruses, SRAS-CoV-2 is made up of four proteins [13,14].

Spike (S) protein forms the namesake crown-like protuberances that are essential to attach the virus to the host cell and determine which cells it targets. Envelope (E) protein forms the envelope. Membrane (M) protein forms the membrane. Nucleocapsid (N) protein protects the viral RNA. Proteins S, E and M together enclose the virus.

Once the virus has penetrated the host cell, its RNA is released, and copies are produced. The resulting virions burst out and spread to other cells, where the process is repeated.

Survival of the virus outside an infected organism [15,16]

Coronaviruses remain infectious for 2—3 h in air, and up to 9 days on smooth non-porous surfaces (stainless steel, plastic, ceramics, glass). By contrast, they do not survive on copper, brass or bronze, which are biocidal.

SARS-CoV-2 has a half-life (50% of viruses inactivated) of 13 h on stainless steel and 16 h on polypropylene. The virus is short-lived on paper and most non-waterproof textiles.

SRAS-CoV-2 is broken down by soap, ethanol-containing gels and solutions (62—71% ethanol), and household disinfectants such as hypochlorite bleach (diluted to 0.1%).

No contamination of HCPs by SARS-CoV-2 during a laparoscopy has yet been reported.

Although the strength of evidence is still low, cautionary measures are in order. All the available scientific and clinical data must be used to ensure the protection of HCPs and prevent viral contamination.

Means to protect HCPs

Means to protect HCPs must be implemented whenever the laparoscopy is performed in a patent infected with SARS-CoV-2, or in the context of the Covid-19 epidemic in a patient with fever or a recent cough, or who has spent time in the last two weeks in a location where the epidemic is active, or who has been in contact with infected persons [17]. Some authors even advocate extending testing for SARS-CoV-2 to all patients awaiting surgery whether or not they have Covid-19 symptoms [8,18]. Measures must include personal protection equipment (PPE) for HCPs, laparoscopy equipment, surgical technique and operating room organisation.

Table 1 Technical measures for preventing contamination of HCPs by SARS-CoV-2.

Prefer the ''closed'' technique for obtaining pneumoperitoneum
Reduce the pneumoperitoneum pressure as much as possible (without compromising safety)
Reduce the power of electrosurgery and ultrasonic dissection
Systematically use laparoscopic smoke aspiration systems
Systematically use particle filters
Prefer intracorporeal anastomosis
Extract excised tissue after complete emptying of the pneumoperitoneum
Fully aspirate the pneumoperitoneum before removing the last trocar

Personal protection equipment for HCPs

The surgery team (surgeon, assistant, scrub nurse or circulating nurse) seem to be less exposed than the anaesthesia team (anaesthetist and anaesthetist's nurse), who are in direct contact with the patient's upper airways, which are the main source of contamination [19]. PPE is only one component of the protection measures. It must be used by every member of the HCP team according to the World Health Organisation (WHO) guidelines [20]. PPE includes long-sleeved fluid protection gowns, lined gloves, goggles (or visors, especially for the anaesthesia teams) [19], and masks.

Conventional surgical masks do not provide sufficient protection in an operating room with a risk of aerosols rich in viral droplets. The N95 respirator masks regulated by the US National Institute for Occupational Safety and Health (NIOSH) are not EC-approved. The FFP2 and FFP3 filtering facepiece masks are more efficient as regards the filtration of aerosols (of saline solution or paraffin oils), with an efficiency of 94% for FFP2 and 99% for FFP3. FFP2 masks meet the filter efficiency criteria of the NIOSH [21]. To be effective, these masks must, however, be used correctly and be properly fitted.

Laparoscopy equipment and surgical technique

The risk of contamination of HCPs is highest during the insertion of trocars, extraction of the excised tissues and removal of trocars at the end of the operation. Technical measures are summarised in Table 1.

As the virus can be present in the digestive tract [22], intracorporeal anastomosis (particularly in colorectal surgery) is to be preferred because it reduces the risk of contamination of the HCPs.

Lastly, there is no data in the literature suggesting that laparoscopy should be systematically replaced by laparotomy during the Covid-19 epidemic.

Organisational measures

The first measure is to raise awareness among HCPs of the risk of contamination and train them in implementing prevention measures. We need not dwell on the now well-known general sanitising measures: frequent hand-washing, permanent wearing of masks, and frequent washing of furniture and floors according to the general rules of hospital hygiene.

The main organisational measures are summarised in Table 2. These measures are to be implemented jointly with the hygiene and administration departments of each hospital.

Table 2 Organisational measures for preventing contamination of HCPs by SRAS-CoV-2.

Train HCPs in protection measures
Set up separate circuits for patients with Covid-19 or suspected of having Covid-19 and for certainly non-Covid-19 patients
Have as few HCPs as possible in operating rooms
Avoid movement or changing of HCPs during laparoscopy
Ventilate the operating room
Manage waste appropriately during and after laparoscopy
Encourage the surgical team to leave the operating room during the intubation and extubation phases
Take general hygiene measures (hand-washing, cleaning of furniture and instruments, etc.)

Disclosure of interest

NB declares competing interest with Gedeon Richter, Storz. KS has competing interest with Sanofi, MSD, FSK, B-Braun, Baxter. JV declares that he has no competing interest.

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