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REVIEW

Extent of infectious SARS-CoV-2 aerosolisation as a result of oesophagogastroduodenoscopy or colonoscopy

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Abstract

Background COVID-19 has caused an unprecedented pandemic and medical emergency that has changed routine care pathways. This article discusses the extent of aerosolisation of severe acute respiratory syndrome coronavirus 2, the virus that causes COVID-19, as a result of oesophagogastroduodenoscopy and colonoscopy.

Methods PubMed and Google Scholar were searched for relevant publications, using the terms COVID-19 aerosolisation, COVID-19 infection, COVID-19 transmission, COVID-19 pandemic, COVID-19 and endoscopy, Endoscopy for COVID-19 patients.

Results A total of 3745 articles were identified, 26 of which were selected to answer the question of the extent of SARS-CoV-2 aerosolisation during upper and lower gastrointestinal endoscopy. All studies suggested high infectivity from contact and droplet spread. No clinical study has yet reported the viral load in the aerosol and therefore the infective dose has not been accurately determined. However, aerosol-generating procedures are potentially risky and full personal protective equipment should be used.

Conclusions As it is a highly infectious disease, clinicians treating patients with COVID-19 require effective personal protective equipment. The main routes of infection are direct contact and droplets in the air and on surfaces. Aerosolisation carries a substantial risk of infection, so any aerosol-producing procedure, such as endoscopy, should be performed wearing personal protective equipment and with extra caution to protect the endoscopist, staff and patients from cross-infection via the respiratory system.

Key words: Aerosol; COVID-19; Lower GI endoscopy; Upper GI endoscopy; Personal protective equipment

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Introduction

The World Health Organization declared COVID-19 to be a pandemic on 11 March 2020, after 20 000 confirmed cases and almost 1000 deaths (World Health Organization, 2020a). As of 8 June 2020, there were 7 085 894 confirmed cases, with 405 168 deaths and 3 180 479 recovered cases (Johns Hopkins University, 2020). This has put global health systems under unprecedented pressure to deal with the crisis while providing the required care for the usual medical and surgical emergencies. Hospitals and medical staff are advised to comply with newly produced policies and guidance by leading societies, Royal colleges, and official health authorities. The safety, effectiveness and logistical management of the health system has been tested by the situation created by COVID-19. This includes infrastructure resource changes, staff management and mobilisation, new equipment provision, and decisions on how to manage elective, semi-emergency, emergency and cancer surgery patients.

The impact on different health disciplines has been huge. With regard to gastrointestinal endoscopy service provision, the British Society of Gastroenterology and the Joint Advisory Group issued initial guidance on indications for endoscopy during the pandemic (British Society of Gastroenterology, 2020). Performing upper and lower gastrointestinal endoscopy for current indications carries greater risks of contracting COVID-19 for both staff and patients. Virus-laden aerosol could come from particles deposited on the floor or carried

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across different areas by medical staff (for example on their shoes). Knowledge of aerosol generation and distribution in clinical areas will help design strategies to reduce the risk of transmission (Hirota, 2020). Understanding the pathogenesis and epidemiology of COVID-19, the minimum load needed to cause infection, the lifespan of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the incubation period and infectivity will enable us to break the infection cycle. This article assesses the risk of aerosolisation of COVID-19 during oesophagogastroduodenoscopy and colonoscopy procedures.

Methods

PubMed and Google Scholar were searched for relevant publications from 21 March 2020 to 5 June 2020, using the following terms: COVID-19 aerosolisation, COVID-19 infection, COVID-19 methods of infection, COVID-19 pandemic, COVID-19 and endoscopy, and Endoscopy for COVID-19 patients. Relevant articles were selected and agreed by two authors by mutual discussion. The agreement consensus rate was 95%. The inclusion criteria were studies that reported aerosol risks in COVID-19 patients, and the exclusion criteria were studies that did not report COVID-19 or had weak methodology, were not written in English or were not indexed on PubMed.

Two authors (AH and TS) selected a total of 3210 abstracts via PubMed. A further 535 articles were added by searching Google Scholar, and from this total of 3745, 391 duplicates were removed. From these 3354 studies, 3114 studies were excluded because they were not relevant (2582 studies) or not about COVID-19 (532 studies). This left 240 full texts available to assess, of which 214 were excluded because they were non-clinical studies (14 reports), not written in English (41), or had weak methodology or were not indexed in PubMed (159 studies). Two authors (AH and TS) agreed the final selection (26 studies). The PRISMA flow chart shows the study selection and exclusion process (Figure 1). The study did not need trial registration or ethics committee approval.

A total of 3745 articles were identified, of which 26 were selected to answer the proposed question of the extent of COVID-19 aerosolisation during upper and lower gastrointestinal endoscopy. All studies suggested high infectivity by contact and droplets.

There is no clinical study reporting the virus load in the aerosol and therefore accurate determination of the infective dose is not known. Likewise the risk of inhaling droplets or aerosolised virus particles as a result of smoke inhalation during laparoscopic procedures

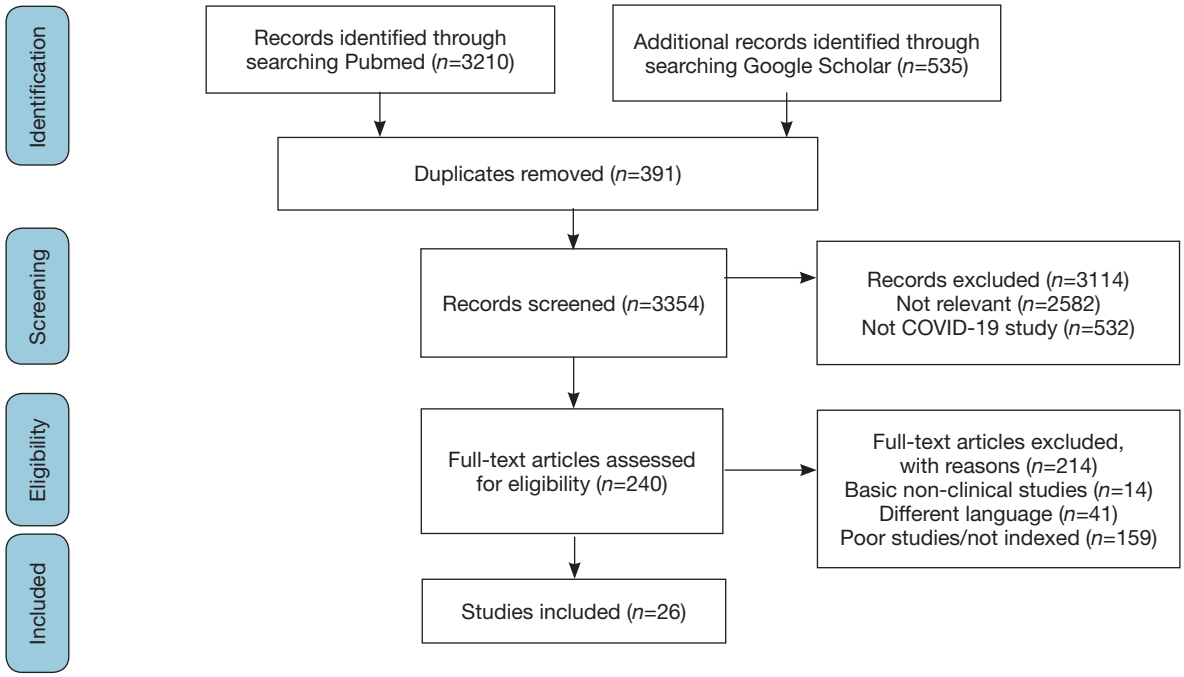

Figure 1. PRISMA flow chart showing the screening, eligibility, inclusion and exclusion of studies with reasons.

is still unknown, although the potential for infection is high. All studies suggested that personal protective equipment should be worn during all aerosol-generating procedures, including laparoscopic operations.

Discussion

The risks associated with aerosol-generating procedures cannot be ignored during the current COVID-19 pandemic. While the surgical approach could change to less invasive procedures to minimise the risk of aerosolising biological fluids (Lisi et al, 2020), other authors and respected surgical societies have suggested avoiding a minimal access approach for the same reasons of minimising the risk of contracting COVID-19 from bodily fluids and pneumoperitoneum gas. **Figure 2** shows the pathogenicity of SARS-CoV-2. There is active virus replication in the tissues of the upper respiratory tract. Virus isolation from stool samples was never successful, irrespective of viral RNA concentration. Peak concentrations were reached before day 5. These findings suggest high pathogenicity and infectivity of SARS-CoV-2, through active pharyngeal viral shedding at a time when symptoms are still mild and typical of infections of the upper respiratory tract.

In terms of the risk of infection, an upper gastrointestinal examination is a high-risk diagnostic and therapeutic procedure, and a lower gastrointestinal exploration is a moderate- to low-risk intervention. In spite of conflicting evidence, there is a risk of aerosolisation during surgical and endoscopy procedures (Sociedad Española de Patología Digestiva and Asociación Española de Gastroenterología, 2020). Droplets can be generated through sneezing, coughing or retching when these procedures are performed with or without sedation.

A report from Wuhan, China, suggested a substantial risk of infection (3.8%) among health professionals, with 14% of them developing the severe form of the disease (Wu and McGoogan, 2020). Although the infection could have been transmitted via contact or droplets, the importance of maintaining a careful and safe approach when caring for COVID-19 patients is clear.

Strict aerosol management and safety precautions are therefore mandatory for operations, including endoscopy procedures, during which there is a minimal distance between the patient and staff, and so infection via droplets is a major concern (Yu et al, 2020). Previous studies showed that the coronavirus (SARS-CoV) that caused severe acute respiratory syndrome could be transmitted if the distance between people was less than 2 metres and therefore transmission through fomites or small aerosols cannot be ruled out (Wong et al, 2004).

Studies from Wuhan showed that 80% of patients were either asymptomatic or developed mild disease (World Health Organization, 2020b). Personal protective equipment used by clinicians should include gloves, hairnet, protective eyewear (goggles or face shield), waterproof gowns and respiratory protective equipment (Gralnek et al, 2020), according to the patient's risk status (having had contact with COVID-19 patients, clinical symptoms of cough, fever, myalgia, sputum production, headache and diarrhoea, and patients who tested positive for COVID-19). High-filter respirators (FFP2/3) should be used for high-risk or infected cases (Centers for Disease Control and Prevention, 2014). However, Chinese authors suggested that protection at biosafety level-3 is required when performing all endoscopic procedures in patients with confirmed or suspected COVID-19 infection (Zhang et al, 2020).

Upper and lower gastrointestinal endoscopy procedures are considered to be aerosol-generating procedures, and therefore transmission of the disease is possible, according to Chinese and Italian reports (Repici et al, 2020; Zhang et al, 2020). Current evidence shows that SARS-CoV-2 is primarily transmitted between people via respiratory droplets and contact routes, while airborne infection, although still possible, has not yet been confirmed in scientific studies (Chan et al, 2020; Liu et al, 2020). There have been no reports of faecal-oral transmission of SARS-CoV-2 to date (World Health Organization, 2020c).

The aerosolisation and infectious extent of SARS-CoV-2 cannot be accurately measured, but potential transmission is a major risk if aerosol droplets are <5 µm diameter (SARS-CoV-2 is approximately 0.125 µm in diameter). Under experimental laboratory conditions,

SARS-CoV-2 can survive in a room for 3 hours, with a half-life of 1.1 hours, and it can remain live or cause potential infection for up to 4 and 6.8 hours on copper and plastic surfaces respectively (van Doremalen et al, 2020). These time frames could vary depending on methodology, culturing and the cells used. This does not mean that the virus inevitably causes infection when a person enters a room that contains SARS-CoV-2 aerosols, but guidelines and protocols produced by the World Health Organization, and organisations such as the British Society of Gastroenterology, the European Society for Gastrointestinal Endoscopy, the American Society for Gastrointestinal Endoscopy and the World Endoscopy Organization should be followed to reduce the risk of infection (Wu and McGoogan, 2020).

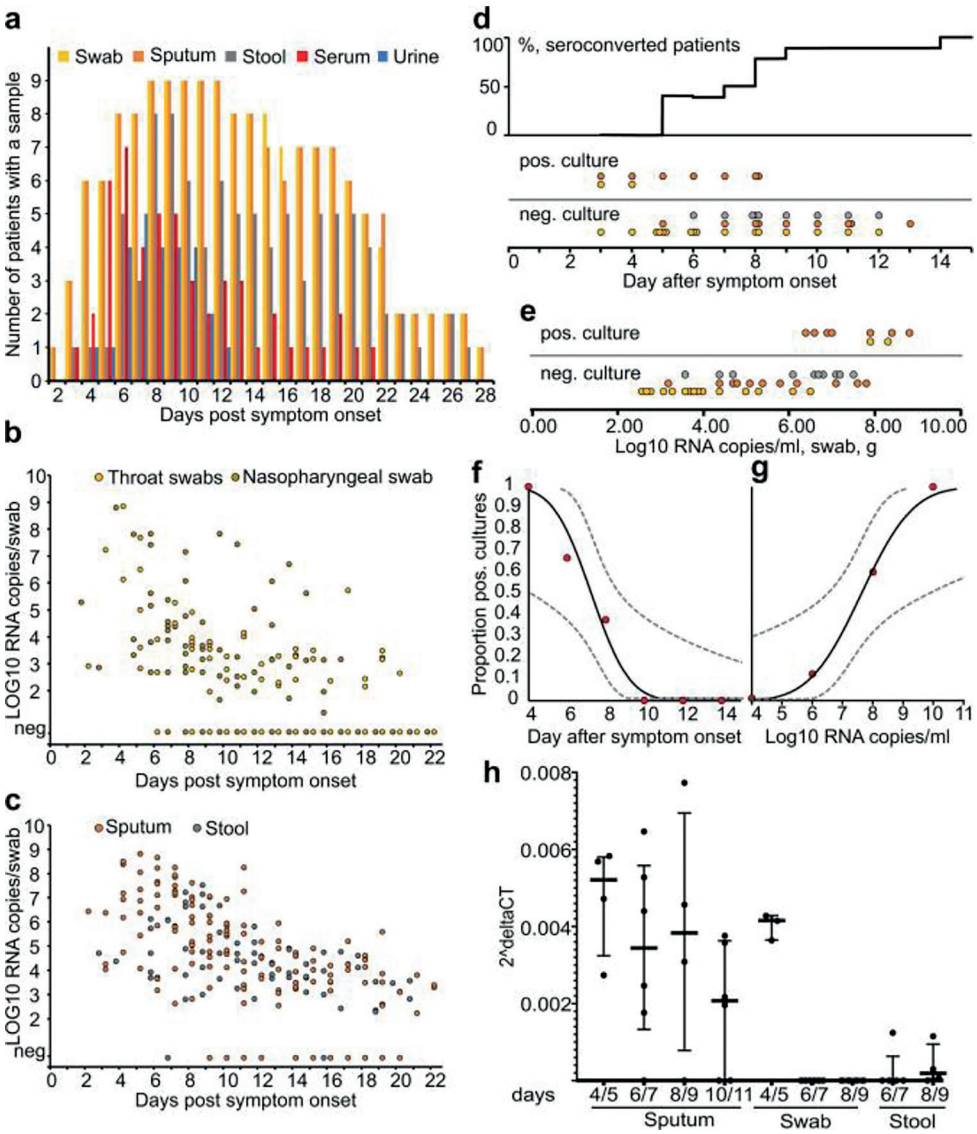

Figure 2. Hallmarks of viral shedding in aggregated samples. a. Samples and sample types per day. b. Viral RNA concentrations in upper respiratory tract samples. c. Viral RNA concentrations in sputum and stool samples. d. Seroconversion and virus isolation success dependent on day post onset of symptoms. Top panel shows fraction of seroconverted patients, bottom shows aggregated results of virus isolation trials. e. Virus isolation success dependent on viral load. f and g. Projected virus isolation success based on probit distributions. The inner lines are probit curves (dose-response rule). The outer dotted lines are 95% CI. For less than 5% isolation success, the estimated day was 9.78 (95% CI: 8.45–21.78) days post-onset and the estimated RNA concentration for less than 5% isolation success was estimate to be 6.51 Log10 RNA/ml (95% CI: -4,11-5.40). h. Subgenomic viral RNA transcripts in relation to viral genomic RNA. Dots represent mean values of RT-PCR data obtained from at least two independent experiments on samples from individual patients. Plots show median values with hallmarks of viral shedding in aggregated samples. From Wölfel et al (2020).

Key points

- Aerosol infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a risk for medical staff and patients.
- Adequate personal protective equipment should be used to reduce the risk of infection during upper and lower gastrointestinal endoscopy procedures and other aerosol-generating procedures.
- The use of personal protective equipment during aerosol-generating procedures should continue until SARS-CoV-2 is no longer a health risk.

Being <5 µm in diameter, aerosol droplets would be expected to settle on surfaces, and direct contact with these surfaces without personal protective equipment could carry a significant risk of infection. The major mode of transmission is droplets that are sneezed or coughed (Chan et al, 2020). Human coronaviruses can remain viable for up to 5 days at temperatures of 22–25°C and relative humidity of 40–50% (which is typical of air-conditioned indoor environments), creating a substantial public health risk (Health Protection Scotland, 2020).

The time after which a room can be entered without a FFP3 respirator can be determined by the number of air changes per hour, as outlined in World Health Organization guidance; general wards and single rooms should have a minimum of six air changes per hour or a flow rate of 16 litres/min, and in negative-pressure isolation rooms there should be a minimum of 12 air changes per hour or a flow rate of 160 litres/min (World Health Organization, 2014).

Viruses are self-replicating units, so an infection can start with just a small number of particles (the 'dose'). The actual minimum number varies between different viruses and the 'minimum infectious dose' for SARS-CoV-2 is not yet known, but it may be around a hundred virus particles (for SARS, the infective dose in mouse models was only a few hundred viral particles). It seems likely that it will only be necessary to breathe in a few hundred or thousand SARS-CoV-2 particles to develop symptoms (Science Media Centre, 2020).

The viral load could not be detected early in tertiary patients (who had acquired infection through contact with patients who had contracted the virus from patients who had been to Wuhan city); thus, it could be speculated that the infectivity of SARS-CoV-2 may gradually decrease on subsequent infections (Xu et al, 2020). There are currently no studies confirming aerosol infection in SARS-CoV-2, but there are similarities with other viruses that are infectious via aerosol transmission (Wax and Christian, 2020).

Colonoscopy involves suction, irrigation and gas insufflation, all of which could produce aerosol. Expression of SARS-CoV-2 has been found in faeces during active disease and also after recovery (Chen et al, 2020). Staff performing gastrointestinal endoscopy for COVID-19 patients or isolated convalescent patients should consider all cases to be infected and take strict protective measures (Tian et al, 2020). Studies have shown that the average viral load in sputum was 7.00×10^6 copies per ml (maximum 2.35×10^9 copies per ml) and samples containing fewer than 10^6 copies/ml never yielded an isolate, possibly indicating the loading dose or infective dose to cause replication and clinical infection (Wölfel et al, 2020) (Figure 2). There is no study of the aerosol load of SARS-CoV-2 to accurately determine the viral infectivity.

Conclusions

Although no clinical studies have confirmed aerosol infection of SARS-CoV-2, this mode of transmission is likely significant. Personal protective equipment is necessary when dealing with suspected or confirmed COVID-19 cases during aerosol-generating procedures.

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Authorship
AH searched PubMed, drafted and edited the paper, TS searched PubMed, critically reviewed and agreed the final version, SE helped in ideation, proofread the paper, provided critical appraisal and approved the final version.

Conflicts of interest
The authors declare no conflicts of interest.

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