

Ground Plan for Performing Emergency Surgery for Suspected and Confirmed COVID-19 Patients

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Abstract

Introduction: The coronavirus disease 2019 (COVID-19) crisis has created a huge challenge for healthcare systems all over the world. Different health policies have been adopted with variable success rates. This study aims to provide a practical pathway for managing surgical patients in the current COVID-19 pandemic.

Methods: A modified framework of local policies and pathways is suggested to deal with acute surgical admissions and semi-emergency conditions. This includes logistic changes in the hospitals' infrastructure, staff allocation, and the use of suitable personal protection equipment.

Results: The introduction of the suggested changes is expected to improve the delivery of the services and to reduce the risks for both patients and staff. About 80 operations have been conducted since the implementation of these changes.

Conclusion: Challenges with the COVID-19 pandemic have required each health system to adequately respond to the crisis by introducing urgent, fundamental changes to the current surgical practices. The local managerial policies of each hospital are likely to evolve throughout the crisis.

Keywords: Covid-19, Emergency surgery, Personal protective equipment

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Introduction

A cluster of cases of pneumonia due to the unknown cause was reported in Wuhan, China in late 2019. This was later confirmed to be due to the virus SARS-CoV-2 (Severe Acute Respiratory Syndrome coronavirus 2), which causes a disease widely referred to as COVID-19 (coronavirus disease 2019). The World Health Organization

(WHO) classified COVID-19 as a pandemic on the 11th of March 2020. As of the 12th April 2020, 84,279 patients had tested positive with 10,612 (12.4%) deaths in the UK, with a front-line National Health Service (NHS) consultant regrettably dying in the fight against COVID-19.

The Public Health England (PHE) organization has provided the healthcare sector with general guidance for assessing patients with COVID-19 (Figure 1).

Recommended PPE for healthcare workers by secondary care inpatient clinical setting, NHS and independent sector

Setting	Context	Disposable Gloves	Disposable Plastic Apron	Disposable fluid-resistant gown	Surgical mask	Fluid-resistant (Type IIR) surgical mask	Filtering face piece respirator	Eye/face protection ¹
Acute hospital inpatient and emergency departments, mental health, learning disability, autism, dental and maternity settings	Performing a single aerosol generating procedure ² on a possible or confirmed case ³ in any setting outside a higher risk acute care area ⁴	✓ single use ⁵	✗	✓ single use ⁵	✗	✗	✓ single use ⁵	✓ single use ⁵
	Working in a higher risk acute care area ⁴ with possible or confirmed case(s) ³	✓ single use ⁵	✓ single use ⁵	✓ sessional use ⁶	✗	✗	✓ sessional use ⁶	✓ sessional use ⁶
	Working in an inpatient, maternity, radiology area with possible or confirmed case(s) ³ – direct patient care (within 2 metres)	✓ single use ⁵	✓ single use ⁵	✗	✗	✓ sessional use ⁵	✗	✓ sessional use ⁶
	Working in an inpatient area with possible or confirmed case(s) ³ (not within 2 metres)	✗	✗	✗	✗	✓ sessional use ⁵	✗	✓ risk assess sessional use ^{6,7}
	Working in an emergency department/acute assessment area with possible or confirmed case(s) ³ – direct patient care (within 2 metres)	✓ single use ⁵	✓ single use ⁵	✗	✗	✓ sessional use ⁵	✗	✓ sessional use ⁶
	All individuals transferring possible or confirmed case(s) ³ (within 2 metres)	✓ single use ⁵	✓ single use ⁵	✗	✗	✓ single or sessional use ^{5,6}	✗	✓ risk assess single or sessional use ^{6,7}
	Operating theatre with possible or confirmed case(s) ³ – no AGPs ²	✓ single use ⁵	✓ single use ⁵	✓ risk assess single use ^{5,7}	✗	✓ single or sessional use ^{5,6}	✗	✓ single or sessional use ⁶
	Labour ward/area – 2nd/3rd stage labour vaginal delivery (no AGPs ²) – possible or confirmed case ³	✓ single use ⁵	✓ single use ⁵	✓ single use ⁵	✗	✓ single or sessional use ^{5,6}	✗	✓ single or sessional use ⁶
	Inpatient care to any individuals in the extremely vulnerable group undergoing shielding ⁸	✓ single use ⁵	✓ single use ⁵	✗	✓ single use ⁵	✗	✗	✗

Table 1

- This may be single or reusable face/eye protection/full face visor or goggles.
 - The full list of aerosol generating procedures (AGPs) is within the COVID-19 IPC guidance (note APGs are undergoing a further review at present).
 - A case is any individual meeting case definition for a possible or confirmed case. <https://www.gov.uk/government/publications/wuhan-novel-coronavirus-intel-investigation-of-possible-cases/investigation-and-initial-clinical-management-of-possible-cases-of-wuhan-novel-coronavirus-wm-cov-infection>
 - Higher risk acute areas include: ICU/HDU; ED resuscitation areas; wards with non-invasive ventilators; operating theatres; endoscopy units for upper Respiratory, ENT or upper GI endoscopy; and other clinical areas where AGPs are regularly performed.
 - Single use refers to disposal of PPE or decontamination of reusable items e.g. eye protection or respirator, after each patient and/or following completion of a procedure, task, or session; dispose or decontaminate reusable items after each patient contact as per Standard Infection Control Precautions (SICPs).
 - A session refers to a period of time where a healthcare worker is undertaking duties in a specific care setting/exposure environment e.g. on a ward round; providing ongoing care for inpatients. A session ends when the healthcare worker leaves the care setting/exposure environment. Sessional use should always be risk assessed and considered where there are high rates of hospital cases. PPE should be disposed of after each session or earlier if damaged, soiled, or uncomfortable.
 - Risk assessed use refers to utilising PPE when there is an anticipated/likely risk of contamination with splashes, droplets of blood or body fluids.
 - For explanation of shielding and definition of extremely vulnerable groups see guidance: <https://www.gov.uk/government/publications/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19>
- Patient use of PPE:** In cohort wards, communal waiting areas and during transportation, it is recommended that suspected or confirmed cases wear a surgical face mask if this can be tolerated. The aim of this is to minimise the dispersal of respiratory secretions, reduce both direct transmission risk and environmental contamination. A surgical face mask should not be worn by patients if there is potential for their clinical care to be compromised (e.g. when receiving oxygen therapy).

Figure 1: Public Health England guidance

However, with the focus on aerosol-generating procedures (e.g., anesthesia, endoscopy, and surgery) that require robust measures to protect both staff and patients, we applied a practical plan to manage operative theatres on a day to day basis. Against this backdrop, we propose new pathways for managing surgical emergencies in the operative theatre complex for patients with either suspected or confirmed COVID-19.

Methods

A modified framework of local policy and pathways is suggested to deal with acute surgical admissions and semi-emergency conditions. We know that a negative pressure operating theatre (1, 2) was proven to be more effective against airborne diseases during the SARS (Severe Acute Respiratory Distress Syndrome) crisis (3), where the risk of cross-contamination was reduced with appropriate use of personal protective equipment (PPE). According to the WHO interim guidelines (19/03/2020) and the Public Health England organization, PPE includes gloves, fluid-resistant surgical masks, goggles, disposable aprons and eye protection on risk assessment. For aerosol-generating procedures or high-risk areas, double gloves, respirators (i.e., N95 or FFP3 standard or equivalent), long-sleeved fluid repellent gowns and face shields/visors/goggles are recommended. In this context, these will be referred to as general PPE and full PPE, respectively.

Keeping in mind the infrastructure of most NHS hospitals, negative pressure theatres (4) may be difficult to achieve. Putting the ventilation off is another option; however, the theatres can become warm and difficult to breath in full PPE, especially with increasing temperature under intense lighting for prolonged procedures for which taking a break may not be an option.

With these limitations, several general and perioperative measures must be implemented.

A. General Measures

A theatre with the shortest passage from the Intensive Treatment Unit (ITU) and hospital wards should be chosen to prevent unnecessary contact with staff during the transfer of a COVID-19 patient. This is named as the 'Designated Theatre' (DT). In case the Operating Theatre (OR) floors are on different levels, only one designated lift will be used for COVID-19 patients. This lift will be accessible exclusively by a secure badge and needs to be marked for all staff and visitors as a COVID-19 lift.

Theatres with positive pressure mean that it would be mandatory for authorized theatre staff to wear surgical masks at all times in all areas of the theatre complex. The PHE organization recommends that ventilation in both laminar-flow and conventionally ventilated theatres should remain fully on during surgical procedures for COVID-19 positive patients and states that air passing from operating theatres to adjacent areas would be highly diluted and does

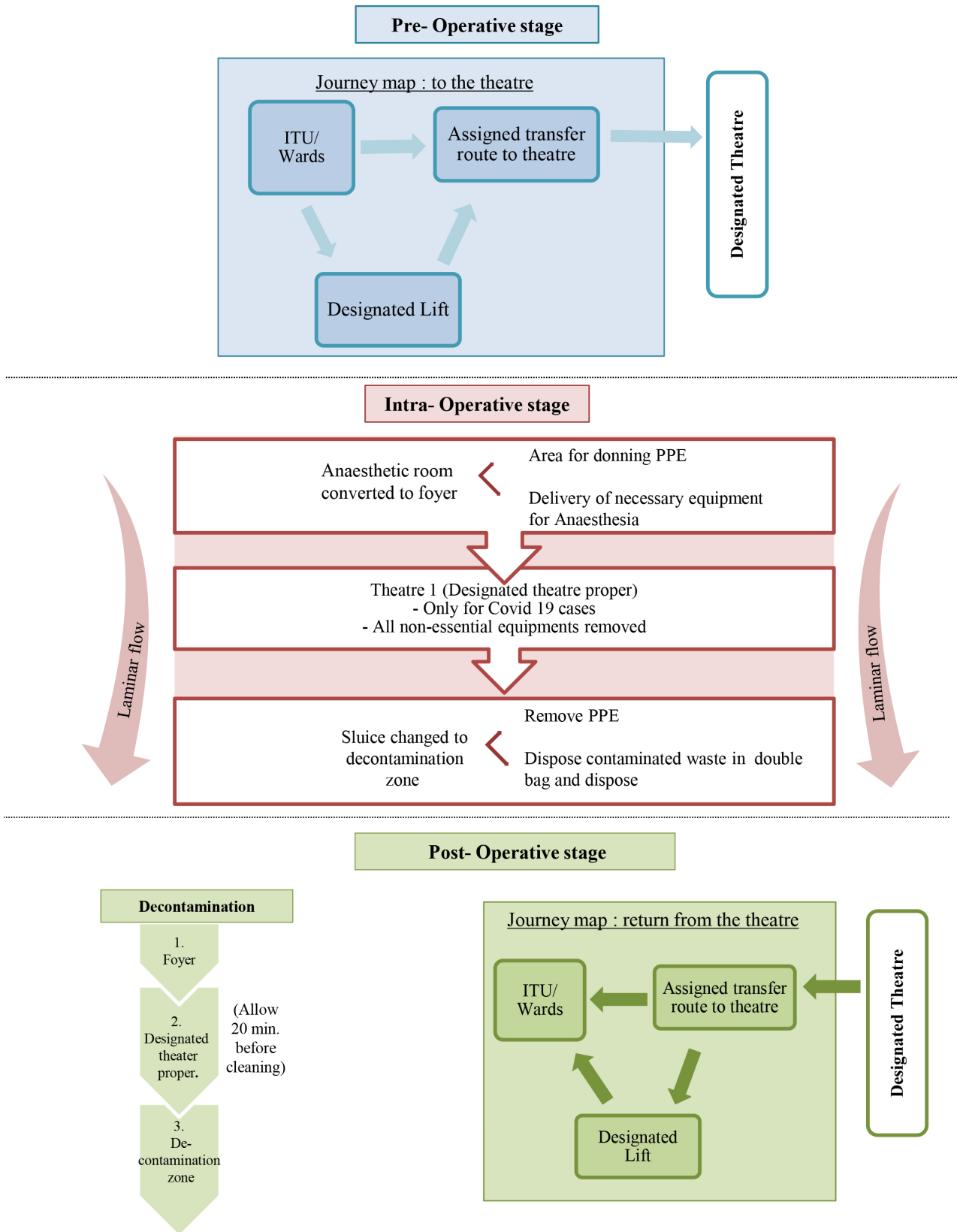


Figure 2: Ground plan for COVID-19 patients requiring emergency surgery

not pose a risk (5). All surgical emergencies should be agreed upon and carried out by the most senior members of the surgical, an aesthetic, and theatre teams. The bleeps of all staff involved in the surgery should be handed over to other members of their respective teams to minimize distractions during

the procedure. All members of the team must be well hydrated and fed and should have emptied their bladders prior to commencing the operation. They should anticipate that communication between team members would be hampered once everyone has donned the full PPE. The hoods pump in dry air

and make communication especially difficult. The operative procedure may take much longer than usual due to these limitations. The safest and quickest operative option with the minimal morbidity risk should be undertaken (e.g., forming a diverting or long-term stoma).

The DT includes:

1. The anesthetic room or the pre-operative area, which is turned into a foyer for donning PPE (6, 7). The door of this room will be modified to include a one-way non-contact pass apparatus (NCPA).
2. The designated theatre proper (DTP) for induction of anesthesia and surgery.
3. The sluice room, which should be turned into a decontamination zone for the removal of PPE and the disposal of contaminated waste.

The boundary area outside the DT must be cleared of any equipment or storage trolleys and should be well demarcated.

Peri-operative Measures

We propose to divide the flow of a COVID-19 patient through the theatre complex into three phases:

First Phase

This is the pre-operative stage in which the roles of the team members are established (Figure 1). The DT team (7) would consist of the anesthetic team (senior anesthetist and anesthesia nurse), the surgical team (senior surgeon and senior surgical assistant), two nurses (scrubbed and circulating), the operating room (OR) technologist, and the OR runner. The ancillary team includes the theatre coordinator, the ward/ITU nurse in charge, security personnel, the operating department practitioner (ODP), and the theatre cleaners. All members coming in direct contact with the COVID-19 patient will need to wear PPE as discussed above (8). It is necessary to make

senior staff available for high-risk situations, such as complex surgical cases. For minor cases, such as simple abscess drainage, more junior staff and a smaller team may be adequate.

The transfer of the patient is initiated by the theatre coordinator by deploying the security and ODP to the ITU/ward. The patient must be directly transferred to the DTP, bypassing the foyer. The OR runner will remain outside the DT. A communication device like a portable transceiver should be available for communication between inside and outside the theatre with the OR runner.

The items of the WHO surgical safety checklist (9) and sign-in will be carried out in the DTP followed by the induction of anesthesia. All team members must anticipate any challenges to be faced and stay ready to avoid delays during the surgery. All patients must be anaesthetized and recovered in the DTP.

Second Phase

This is the intra-operative stage. The process of donning in the anesthetic room or pre-operative area should be closely supervised by an experienced member to minimize risks. The most experienced surgeon and a senior assistant from the surgical team are to perform the procedure. A handheld communication device will be kept with the OR runner and the circulating nurse to allow the team to request any additional anesthetic or surgical equipment that may be needed during the surgery. The OR runner can then send in the item through the NCPA.

Wherever possible, disposable anesthetic and surgical equipment should be used. Re-useable items should be limited; those used need to be processed in line with the local hospital guidelines (Figure 2). All specimens must be double-bagged, marked as COVID-19, then placed in a labelled pathology specimen transport container to be delivered to the


	Pre-Operative	Intra-Operative	Post-Operative
Theatre Coordinator	Prepares the designated theatre and oversees the process.		Confirms readiness of the ward / ITU to receive the COVID patient Inform security to assist transfer.
Ward/ ITU Nurse in charge	Activates security personnel once theatre is ready		Ensures patient safely received in the ward/ITU.
Security	Initiates clearing and isolating the assigned route for transfer	Transferring staff will need appropriate PPE	Ensures return route is clear
ODP (Operating Department Practitioner)	Ensures safe transfer		Care of post-operative patients
OR Runner	Remains outside designated theatre to limit any unauthorized entry Brings all equipment needed into the foyer	Places requested items needed into foyer	
OR Nurses (2) Scrubbed Circulating	Don full PPE Scrub nurse prepares trolley	Circulatory nurse : Contact OR runner for additional equipments and collect it from the foyer	Double bag any specimen and send to the laboratory
OR technician	Don full PPE + Prepare OT.		
Anaesthesia team: Senior anaesthetist Anaesthesia nurse	Don full PPE + Ensure Intubation trolley ready.	Induction, intubation and maintenance of anaesthesia accordingly to recommended guidelines for Covid 19 patients.	Extubation and recovery Check and record all controlled drugs used
Surgeon : Senior Surgeon Senior Surgical assist	Don full PPE and liaise with theatre co-coordinator	Use dispensable surgical equipments wherever possible	

Figure 3: Members in the designated theatre team and their roles

pathology reception after the surgery. Specimen handling is done in full PPE.

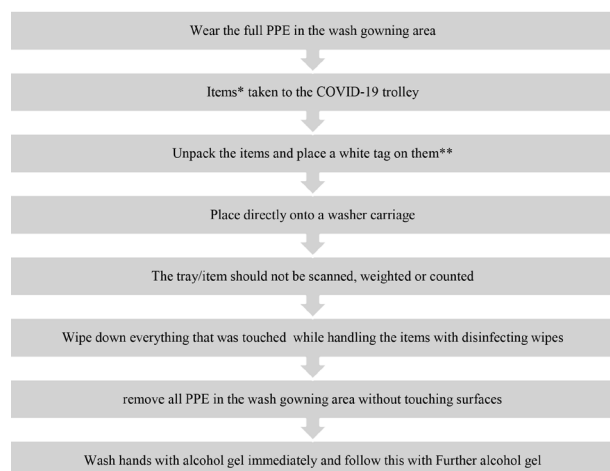
Third Phase

This is the post-operative stage. Staff other than the anaesthetist and the ODP will leave and remove or refresh their PPE in the decontamination zone. Doffing of the PPE (10) should be carried out in the correct order under close supervision. Recovery and extubation will be performed in the DTP. Another option is for the full theatre team to stay in the DTP in full PPE until 20 minutes after extubation to minimize the risk of exposure in common areas of the theatre complex; this would also allow the team to start the cleaning process in the DT and minimize the number of staff entering the DT (5). When the patient has suitably recovered, the theatre coordinator will confirm the readiness of the ward or ITU to receive the patient. The patient will then be moved by following the same steps as transferring the patient to theatre. If the OR floors are on different levels with respect to the ITU/COVID floors, then different options can be considered. As the theatre workload is reduced through the cancellation of elective procedures, some of the theatre rooms can be utilized as ITU rooms, meaning that the patients can be operated upon and postoperatively managed within the same department. For other patients who do not require the ITU, they can be transferred to the respective wards through dedicated corridors and lifts.

The DT must be deep-cleaned adequately between each case. A gap of 20 minutes (5) should be allowed before this process to allow aerosolized virus particles to be removed by the ventilation system or to settle on surfaces. After the DT has been empty for 20 minutes, cleaning can begin with the foyer, then

DTP, and lastly the sluice room (11). The cleaning staff should wear full PPE. All the flat surfaces in the DT need to be cleaned with special attention to the operating table, stools, and monitors.

As most of the DTs in the NHS will be under positive pressure, other flat surfaces in common areas of the theatre complex within a ten-meter radius must also be cleaned after surgery. It is very difficult to know what radius away from the OR theatre door should be cleaned, but in addition to the leading theatre corridor, the two-meter radius away from the OR theatre door should be cleaned (5). The rapid dilution of these aerosols by operating theatre ventilation will protect operating room staff. The air passing from operating theatres to adjacent areas will be highly diluted and is not considered to be a risk (5) (Figures 3 and 4).



*All items that have been exposed to a suspected or positive COVID-19 patient should arrive to the unit double bagged and clearly marked with COVID-19
 **White tag ensures the clean room sends the items back for another wash and to be processed as normal

Figure 4: Handling of items in contact with COVID-19 patients

Intercollegiate General Surgery Guidance on COVID-19		
<p>Emergency Surgery</p> <ul style="list-style-type: none"> - Test all for COVID-19 - Treat all as +ve - CT thorax in last 24 hours - Add CT thorax if having CT abdo 	<p>Planned Surgery</p> <ul style="list-style-type: none"> - Risk assessment for COVID-19 - Greater risks of surgery - Consent - Risk-reducing strategies (e.g. stoma) 	<p>PPE</p> <ul style="list-style-type: none"> - PPE for all laparotomies - Unless COVID-19 negative (beware false negative) - Include eye protection - Practise donning & doffing
<p>Theatre</p> <ul style="list-style-type: none"> - Minimum staffing levels - All staff PPE including visors - Stop +ve pressure ventilation - Smoke extraction - Intubation / extubation in theatre 	<p>Laparoscopy</p> <ul style="list-style-type: none"> - Generally should not be used - Filters etc. difficult to implement - Appendicitis: open / conserv. - Cholecystitis: conserv. / cholecystostomy 	<p>Endoscopy</p> <ul style="list-style-type: none"> - Emergency only - Follow guidance from BSG - Upper GI endoscopy requires full PPE

Figure 5: The Intercollegiate General Surgery Guidance on COVID-19

Results

We conducted 80 operations for general surgery, orthopedics, urology, and gynecology since the application of the new changes. Six COVID-19 (7.5%) patients were included. We have two surgical staffs diagnosed with COVID-19, though it's not clear where the infection took place and what the method of the infection was.

Discussion

The four Royal Colleges of the UK and Ireland have issued the Intercollegiate General Surgery Guidance on COVID-19 [Figure 5]. They have provided general pathways on indications of surgery and how to manage surgical conditions during the COVID-19 crisis. The surgical specialty is a fundamental part of the daily care and the implications are therefore huge. There are several areas of controversy that have arisen as a result, including the feasibility and practicality of maintaining emergency surgery provision, open versus laparoscopic technique in an emergency, semi-emergency and cancer surgery cases, staff protection, the role of pre-operative testing for COVID-19, and the performance of chest CT scans. The semi-emergency procedures include recurrent cholecystitis, empyema of the gallbladder, gallstone pancreatitis, as well as bariatric conditions that cannot wait for elective operations such as band slippage, nutrition problems, anastomosis obstruction, or difficult cases of obesity and uncontrolled diabetes. Needless to say, the management of the surgical manpower in the COVID-19 pandemic is a new experience.

Intercollegiate guidance recommends that positive pressure ventilation be stopped. In the absence of negative pressure theatres, stopping positive pressure ventilation may stop all air circulation. Aerosol-generating procedures may produce droplets that quickly settle down within a couple of minutes; however, microdroplets in the size range of 10 µm or smaller can stay suspended for much longer, possibly for twenty minutes or longer in closed environments with no or inadequate ventilation. Microdroplets may form even with simple activities like talking. For simple droplets, WHO recommends adequate ventilation of 60 L/s per patient (12, 13). For aerosol-generating procedure and operating theatres, the WHO airflow recommendation is at least 160 L/s, or, in negative pressure theatres, at least 12 air changes per hour (12, 13).

The PHE organization recommends that ventilation in both laminar flow and conventionally ventilated theatres should remain fully on during surgical procedures for COVID-19 positive patients and states that air passing from operating theatres to adjacent areas would be highly diluted and does not pose a risk (5, 13).

The time required for clearance of aerosols, and thus the time after which the room can be entered

without a class three filtering facepiece (FFP3) respirator, can be determined by the number of air changes per hour (ACH) as outlined in the WHO guidelines: in general wards and single rooms, there should be a minimum of 6 air changes per hour; in negative-pressure isolation rooms, there should be a minimum of 12 air changes per hour. Where feasible, environmental decontamination should be performed when it is considered appropriate to enter the room or area without an FFP3 respirator. A single air change is estimated to remove 63% of airborne contaminants, whereas after five air changes, less than 1% of airborne contamination is thought to remain. A minimum of 20 minutes (i.e., two air changes) is considered pragmatic in hospital settings where the majority of these procedures occur (5, 13).

There are currently no guidelines or studies on the frequency of testing or ideal tests for all medical staff to decrease the risks of cross-infections to the patients or other staff.

Patients with surgical emergencies and trauma will continue to present to the hospitals and departments need to continue providing a high standard level of care needed and should not be distracted by COVID-19 management and requirements. This part of the service will need close attention to make the patient's journey swift and to ensure the least possible complications.

Staff education and protection are vitally important to maintain efficient manpower on the ground. It is mandatory to maintain physical and mental well-being to maximize their efforts.

Local hospitals may be not able to cope at one stage and critical incidents may be reported. Therefore, every trust and hospital should expect and prepare for the call of help to the most affected part of the country or local region.

China deployed over 42,000 medical workers from across the country, including from the military, to the Hubei province and its capital Wuhan when the virus spread like wildfire and infected thousands of people (14). Chinese health authorities adopted strict pathways and policies for PPE, logistic changes, isolation of hospitals and wards, procedural changes, and other policies.

There will still be unknown risks of cross-infection from medical and nursing staff to the patients and there are no specific studies that confirm this issue. However, the more than 3000 (3.8%) COVID-19 infections among healthcare workers in China signals the importance of appropriate PPE and policies during the crisis (15). To reduce the infection risks for the medical team, Chinese authorities suggested patient isolation, three-layered PPE for medical teams, and 14-day post-deployment isolation and observation of the staff with twice testing for COVID-19 on day 1 and day 10 (16). As the scale and severity of the COVID-19 infection become clearer, each hospital must make changes and prepare its infrastructure to deal with this unprecedented pandemic and medical emergency.

A major aspect of each hospital policy is the cost-effectiveness of advanced versus effective PPE. There are a variety of approaches to choosing PPE. Because of the huge demands on PPE, some developed countries including the UK have ordered different PPE from other countries. The advanced PPE would include double-pairs of gloves, long-sleeved water-tight gowns, FFP3 respirators, and visors. The cost of these instruments is variable but the average cost would be £70-£100 per person. On the other hand, the basic PPE would include single-pairs of gloves, disposable plastic aprons, surgical masks, and eye protection; this may cost up to £15 per person. The choice of PPE is justified by the clinical judgment.

Conclusion

The COVID-19 crisis has called for the healthcare

community to act as a global team to tackle the series of unprecedented events awaiting ahead. This can be done by sharing novel ideas built on up-to-date and rapidly evolving scientific information on COVID-19. The pathways outlined in this article may, therefore, act as a structure for hospitals to help safely manage emergency surgical COVID-19 patients. The experience of COVID-19 has given birth to a situation that would likely result in a paradigm shift in our style of working once this crisis is over.

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Conflicts of interests: None declared.

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