KJA
Korean Journal of Anesthesiology

Anesthesia guidelines for COVID-19 patients: a narrative review and appraisal

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Review Article

Korean J Anesthesiol 2020;73(6):486-502
https://doi.org/10.4097/kja.20354
pISSN 2005-6419 • eISSN 2005-7563

Received: June 30, 2020
Revised: July 10, 2020 (1st); July 14, 2020 (2nd)
Accepted: July 14, 2020

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The coronavirus disease 2019 (COVID-19) pandemic has challenged health systems globally and prompted the publication of several guidelines. The experiences of our international colleagues should be utilized to protect patients and healthcare workers. The primary aim of this article is to appraise national guidelines for the perioperative anesthetic management of patients with COVID-19 so that they can be enhanced for the management of any resurgence of the epidemic. PubMed and EMBASE databases were systematically searched for guidelines related to SARS-CoV and SARS-CoV-2. Additionally, the World Federation Society of Anesthesiologists COVID-19 resource webpage was searched for national guidelines; the search was expanded to include countries with a high incidence of SARS-CoV. The guidelines were evaluated using the Appraisal of Guidelines for Research and Evaluation II tool. Guidelines from Australia, Canada, China, India, Italy, South Africa, South Korea, Taiwan, the United Kingdom, and the United States of America were evaluated. All the guidelines focused predominantly on intubation and infection control. The scope and purpose of guidelines from China were the most comprehensive. The UK and South Africa provided the best clarity. Editorial independence, the rigor of development, and applicability scored poorly. Heterogeneity and gaps pertaining to preoperative screening, anesthesia technique, subspecialty anesthesia, and the lack of auditing of guidelines were identified. Evidence supporting the recommendations was weak. Early guidelines for the anesthetic management of COVID-19 patients lacked quality and a robust reporting framework. As new evidence emerges, national guidelines should be updated to enhance rigor, clarity, and applicability.

Keywords: Anesthesia; Coronavirus infections; COVID-19; Guidelines; Perioperative management; Perioperative medicine; Review.

Introduction

China reported the first outbreak of the novel severe acute respiratory syndrome-related coronavirus (SARS-CoV-2) in Wuhan on 7 January 2020 [1]. As of 25 June 2020, coronavirus disease 2019 (COVID-19) had become a pandemic with more than 9 million cases with 2% critically ill and 9% deceased [2]. Importantly, healthcare workers accounted for 3.8% of the cases in China and 11% in Italy [3]. Virus transmission is through respiratory droplets and fomites, which places anesthetic staff at a high risk of nosocomial infection. Although the virus has been reported to be air-borne [4], this has not yet been

confirmed in clinical studies.

Following the rapid and global spread of the virus, numerous guidelines have been published by national anesthesia societies to provide anesthetists with insights into the management of COVID-19 patients and the risk of infection during aerosol-generating procedures (intubation, extubation, airway suctioning) associated with anesthesia [5]. Ideally, guidelines should have scientific rigor, and they should be presented with clarity. They should also apply to practitioners internationally, irrespective of the minor variations in practice. An objective framework for developing and appraising clinical guidelines is provided by the Appraisal of Guidelines for Research and Evaluation (AGREE) II tool [6]. As various countries move from the containment phase to the gradual relaxation of community restrictions, the second surge of infections is anticipated.

The primary aim of our review was to appraise national guidelines on the anesthetic considerations for COVID-19 patients presenting for surgery and evaluate their quality with the AGREE II tool. Through updates, guidelines can be refined to ensure that they are more robust, and they can equip anesthetists for the potential viral resurgence.

Materials and Methods

Search strategy and selection of sources of evidence

We conducted a systematic search of the PubMed and EMBASE databases using the combination of Medical Subject Heading (MeSH) and keywords (["anesthesia" or "anesthesiology"] OR ["airway management"] OR ["intubation"]) AND (["SARS" OR "SARS-CoV" OR "SARS-CoV-2" OR "COVID-19" OR "Coronavirus"]) for guidelines/studies published between 1 Jan 2002 and 16 May 2020. To capture new guidelines that had not been indexed in these databases, national anesthesia organizations, with links to their official websites listed on the World Federation of Society of Anesthesiologists (WFSA) [7] COVID-19 resource webpage (up to 28 May 2020), were interrogated because it represents anesthesia societies from over 150 countries. We also expanded our search for guidelines from countries (China, Hong Kong, Singapore, and Taiwan) that were affected by the SARS-CoV epidemic in 2003 [8]. Guidelines from Hong Kong and Singapore, which reported SARS previously, were not endorsed by their official national societies, and they were excluded. The bibliographies of the retrieved articles were manually screened for additional relevant material.

Eligibility criteria

Only articles written in English and Chinese were included because the two co-authors who conducted the search were proficient in both languages. Articles that reported relevant aspects of perioperative anesthetic management of patients with COVID-19 were included. Two reviewers (SO and WYL) conducted the search independently and screened all article types for eligibility using their titles and abstracts. Duplicate and irrelevant articles were excluded. Articles that did not address the primary objective and those that were correspondences and editorials were also excluded. Discrepancies were discussed and resolved by PK.

Critical appraisal of sources of evidence

SO and PK independently appraised each eligible national guideline using the AGREE II instrument [6] (Supplementary Table 1). The AGREE II instrument has six domains (with 23 items) and two global rating items. The six domains were scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability, and editorial independence. Each item in the domain is scored on a seven-point scale (1 = minimum to 7 = maximum). Total scores were scaled to a percentage of the maximum score in each domain; for example, 0% if each reviewer scored 1 and 100% if each reviewer scored 7. The AGREE II instrument has been validated and tested for inter-rater reliability.

In addition, full manuscripts of extracted articles from the literature search were analyzed independently by SO and WYL and graded according to the level of evidence as defined by the Centre for Evidence-Based Medicine, Oxford [9].

Results

Nineteen national guidelines from Australia, Canada, China, India, Italy, South Africa, South Korea, Taiwan, the UK, and the USA described the anesthetic management of COVID-19 patients [10–28]. China had the highest score for Scope and Purpose of guidelines followed by South Korea and the UK. The UK and South Africa scored the highest for the Clarity of guidelines. Among the domains, editorial independence had the lowest score, followed by rigor of development and applicability. Spearman correlation analysis of reviewer scores of all domain items demonstrated good inter-rater reliability ($\rho = 0.714$, $P < 0.001$, 95% CI: 0.436–0.868). A summary of the results is provided in Table 1.

There was a paucity of high-quality evidence supporting the current recommendations. Of the 63 articles retrieved from the literature search, only one systematic review (level 2) in 2012 re-

Table 1. Summary of AGREE II Results on National Anesthesia Guidelines for the Management of a COVID-19 Patient

AGREE II Domains	Australia/ New Zealand	Canada	China	India	Italy	South Africa	South Korea	Taiwan	UK	US
Domain 1 Scope and purpose	63.9	27.8	75.0	50	44.4	61.1	66.7	44.4	66.7	63.9
Domain 2 Stakeholder involvement	58.3	33.3	69.4	58.3	58.3	69.4	58.3	58.3	63.9	58.3
Domain 3 Rigor of development	11.5	3.1	22.9	13.5	8.3	15.6	13.5	17.7	25.0	19.8
Domain 4 Clarity of presentation	69.4	41.7	69.4	58.3	63.9	77.8	61.1	52.8	83.3	63.9
Domain 5 Applicability	39.6	25.0	43.8	27.1	31.3	50.0	29.2	35.4	43.8	31.3
Domain 6 Editorial Independence	0.0	0.0	0.0	41.7	0.0	0.0	82.6	0.0	0.0	0.0

Values are presented as percentage. Spearman correlation analysis of reviewer scores of all domain items demonstrated good inter-rater reliability; $\rho = 0.714$ ($P < 0.001$, 95% CI: 0.436–0.868).

lated aerosol-generating procedures to the infections of health care workers [29], and one prospective single-center study (level 3) in 2006 focused on simulation [30]. The remainder of the reports were predominantly retrospective studies, case reports/series (level 4), and expert opinions (level 5) that focused on infection control and intubation. The results of the literature search are shown in Supplementary Table 2.

Guidelines on preoperative management

Preoperative evaluation, screening, and prioritization for surgery

The details on preoperative guidance varied. China and India detailed preoperative screening of history, symptoms, and investigations while South Africa used a brief checklist [15,17,20]. Australia recommended using telemedicine for preoperative assessment, counseling, consent, and a thorough airway assessment [10]. The UK through the Difficult Airway Society focused specifically on the MACOCHA (Mallampati III or IV; Apnea syndrome [obstructive]; Cervical spine limitation; Opening mouth-3 cm; Coma; Hypoxia; Anesthesiologist-non trained) score to assess and predict a difficult airway [24,31]. Only the USA linked preoperative screening with viral testing and prioritization for surgery involving a multidisciplinary team [26]. Recommendations on scheduling elective surgery during the pandemic were provided by Canada, India, South Africa, the UK, and the USA [12,17,20,24,26].

Infection control and personal protective equipment

This was the focus of all the guidelines. All countries recommended airborne precautions and Personal protective equipment (PPE) training [10–28]. There was unanimous agreement on the use of full PPE (N95 mask or powered air-purifying respirator (PAPR), face shield or goggles, gown, hat, double gloves) for aerosol-generating procedures and hand hygiene when donning and after doffing PPE [10–28]. All countries (apart from India and South Korea), recommended a buddy system for PPE donning. High-risk healthcare personnel who were pregnant, immunocompromised, or older than 60 years with cardiorespiratory diseases were advised by the UK to refrain from airway management [23,24]. The number and position of staff present in the inner and the outer rooms, the types of PPE, including the position of equipment and monitors, were detailed by Italy and the UK [19,24]. Other recommendations included using a negative pressure operating theater with warning signs [10–21,23–28], placing a hydrophobic filter interposed between the face mask/endotracheal tube and the breathing circuit or the reservoir bag [10–28], and using disposable equipment [10–16,18–28] where possible. A clear plastic sheet to limit the aerosol spread and the use of forced-air warming blankets only in intubated patients were recommended by Australia [10].

Training and resource planning

Simulation training for the provision of anesthetic care was advocated by Australia, Canada, China, India, Italy, the UK, and the USA [10–19,23–28]. In addition, team briefing before surgery was recommended by Australia, Italy, South Africa, the UK, and the USA [10,11,18,23–28]. China, India, and South Korea addressed fatigue by deploying several airway and anesthetic teams to support hospitals and operating theaters [14–17,21]. All guidelines (except those from Canada and Taiwan) detailed the most direct route for patient transfer to the operating theatre: bypassing the holding area with the patient wearing a surgical mask [10,11,14–28].

Evidence

Apart from one level 2 and one level 3 evidence studies, the evidence relating to preoperative management was weak (level 4 and 5 evidence), and it focused on infection control [29,30]. Reports from the SARS outbreak in 2003 detailed risk factors for the infection of healthcare workers related to PPE use and aerosol generation [29,30,32–34]. Recent reviews on the preoperative management of COVID-19 patients also described operating room opti-

https://doi.org/10.4097/kja.20354

mization and infection control and the rational use of PPE [35,36].

Guidelines on intraoperative management

Intubation

All guidelines focused on the reduction of aerosol generation during procedures and limiting the exposure of healthcare personnel [10–28]. Recommendations included a rapid sequence induction and intubation by the most experienced airway personnel and the use of a videolaryngoscope [10–28]. Canada and the UK recommended using intravenous ketamine for induction in patients with hemodynamic instability [12,23]. Manual ventilation was to be avoided and, if required, small tidal volumes were to be delivered via two-handed facemask ventilation, with the VE hand position preferred to the C hand position [24] for a better mask seal. The Difficult Airway Society in the UK also recommended meticulous attention to preoxygenation, including optimizing patient positioning at induction to maximize a safe apnea time [24]. Only Italy suggested apneic nasal oxygenation delivery at a flow rate of 3 L/min during airway manipulation [18]. Positive pressure ventilation was only to be commenced after intubation and inflation of the tracheal tube cuff [10–20,22–28] to at least 5 cmH_2O above the peak inspiratory pressure [24]. Awake fiberoptic intubation, including the use of high-flow nasal oxygen and non-invasive ventilation was discouraged by all guidelines (except for Canada and South Africa). Only Australia, Italy, and the UK provided specific recommendations for the management of a difficult airway [10,11,18,19,23,24]. These included using the VORTEX approach [37], intubation via a supraglottic airway device (SAD), and employing the scalpel bougie over the needle cannula approach in front of neck access in "cannot intubate, cannot oxygenate" scenarios [10,19,24]. Other heterogeneous recommendations included a smaller sized endotracheal tube, avoidance of cricoid pressure (to minimize coughing) [19], and loading the endotracheal tube routinely with an introducer [10,11].

Use of SAD

There is no consensus on its use as the primary airway device for general anesthesia. China recommended its use [15]; Australia, Canada, Italy, and the UK recommended it only for airway rescue [10,12,19,23,24]. If a second-generation device is used, ensuring a leak-free seal is recommended [24].

Regional anesthesia

Regional anesthesia, where possible, has been advocated by Australia, China, India, and the USA [10,14–17,25–28]. Thrombocytopenia and coagulopathy should be excluded before neuraxial techniques, especially in patients with severe COVID-19 disease [38]. Although SARS-CoV-2 has been demonstrated in cerebrospinal fluid and brain tissue on autopsy, spinal anesthesia in obstetric parturients with COVID-19 has been reported to be safe [39]. For peripheral nerve blocks near the head and neck area, airborne precautions may be considered [40]. In addition, confirming the success of the block reduces the need for emergent conversion to general anesthesia [40].

Extubation

Extubation recommendations targeted at minimizing cough varied, and they included deep extubation, SAD exchange, administration of opioids, lidocaine, dexmedetomidine [10,11,24], glycopyrrolate [22], and prophylactic antiemetics [12,17,27,28].

Evidence

Evidence supporting airway management and endotracheal intubation was initially derived from a systematic review on aerosol-generating procedures and infection in healthcare workers (level 2 evidence) and case reports (level 4 evidence) published on SARS [29,33,34,41–44]. Recent reports on COVID-19 patients (level 4 and 5 evidence) have been published [14–16,45–51]. A recent retrospective review (which included an expert panel) of the emergency intubation of 202 patients with COVID-19 reported that hypoxemia (oxygen saturation < 90%) was common and associated with hypotension, cardiac arrest, and pneumothorax [14]. The authors recommended head elevation for intubation with propofol dose reduction, fluid boluses, or inotropes (to avoid hypotension). A ventilation protective strategy utilizing small tidal volumes to minimize barotrauma was recommended [14].

Guidelines on postoperative management

Patient transfer

Most guidelines proposed that the patient should be recovered in the operating theater [10,11,15,16,25–28]. If disconnection from the breathing circuit is required, clamping the endotracheal tube before disconnection was recommended [10–12,19,24,26,27].

Postoperative cleaning and disinfection

Australia, Canada, China, India, Taiwan, the UK, and USA detailed environmental disinfection [10–17,22–28]. Australia and the UK recommended waiting 20 to 30 minutes between cases to allow for operating theater cleaning and air changes [10,23]. All guidelines advocated the disposal of waste into labeled bins [10–

28]. Additionally, Australia, China, India, South Africa, South Korea, Taiwan, and the USA recommended sealing all contaminated equipment for disinfection in double zip-locked bags [10,11,15,17,20–22,26]. China and South Korea proposed the replacements of the end-tidal carbon dioxide sample line and water trap [15,21].

Staff monitoring and welfare

Australia, Italy, the UK, and the USA [10,19,23,26] recommended a team debriefing event, while Canada encouraged incident reporting of adverse events [12]. With regards to staff surveillance, Australia and the USA required staff to maintain a logbook of clinical exposure, while China required daily surveillance of temperature and respiratory symptoms [10,15,16,26,28]. Additionally, Australia, Canada, South Africa, the UK, and the USA provided support services on mental well-being [10,12,20,23,26].

Evidence

There was little evidence on postoperative management apart from a retrospective study (level 4 evidence) from China that reported surveillance and a 14-day quarantine of a team of anesthesiologists who performed intubation on all COVID-19 patients in two hospitals [52].

A summary of guidelines for the anesthetic management of COVID-19 patients is provided in Tables 2–4.

Guidelines on subspecialty anesthesia

Obstetric anesthesia

National guidelines on the perioperative anesthetic management of obstetric patients with COVID-19 were scarce. Australia, China, Taiwan, the UK, and the USA recommended neuraxial anesthesia as the technique of choice for cesarean delivery [10,15,22,23,25–28]. The use of nitrous oxide/oxygen mixture for labor analgesia was controversial. The UK endorsed its use with a viral filter, but Australia and Taiwan did not [10,22,23]. Evidence from retrieved articles was mainly of level 4 and 5 quality. An expert panel review recommended screening patients for COVID-19 symptoms remotely and observing droplet and contact precautions in the labor ward [53]. Parturients were to wear surgical masks as increased ventilation during labor and symptoms could predispose to airborne transmission [54]. Two studies reported safe administration of epidural and spinal in COVID-19 patients who underwent cesarean section [39,55]. However, a higher incidence of maternal hypotension was reported [55]. Combined spinal and epidural was recommended for anticipated prolonged procedures to minimize conversion to general anesthesia [56]. Thrombocytopenia, which may be present in COVID-19 infections, was to be excluded. Epidural was recommended for labor analgesia to reduce the need for general anesthesia if urgent delivery is required. Category 1 cesarean section delivery should be avoided by close fetal monitoring [42,56]. Patients should be informed of potential delays due to PPE donning [42].

Pediatric anesthesia

Australia, Canada, and the UK provided guidelines for pediatric anesthesia [10,13,23]. Aerosol generation from crying was to be minimized by sedation, parental presence, and deep extubation [10,13]. Inhalation induction was to be best performed with a circle system, utilizing the lowest gas flows. Airway management was to be performed by trained pediatric staff, and a cuffed endotracheal was recommended [10,13,23]. Recommendations for difficult airway management included using video laryngoscopy primarily, followed by fiberoptic intubation through a SAD, combined video laryngoscopy with fiberoptic bronchoscopy, and fiberoptic bronchoscopy alone [13]. The UK also highlighted the need to exclude pediatric multisystem inflammatory syndrome associated with COVID-19 [23]. The literature review revealed only expert opinions and narrative reviews (level 5 evidence) that supported the guidelines from Australia, Canada, and the UK [13,57].

Cardiothoracic anesthesia

Advanced hemodynamic monitoring such as transesophageal echocardiography can be used to guide fluid therapy and vasoactive drugs, especially for COVID-19 patients with multi-organ dysfunction presenting for cardiac surgery. In addition, blood conservation and rigorous evaluation of coagulation are needed for coagulation abnormalities [58]. For thoracic anesthesia, viral filters and clamps should be placed on the double-lumen tube before opening it to the atmosphere so that the release of positive pressure within the lung occurs through a viral filter. In addition, ventilation should be withheld and a swivel connector with a self-sealing valve should be used if the breathing circuit is to be accessed for procedures. Bronchoscopes are significantly contaminated, and disposable flexible bronchoscopes should be used where possible. Suctioning of the airways should be performed before reversing neuromuscular blockades [59,60].

Neuroanesthesia

Full PPE for aerosol-generating procedures should be used for trans-sphenoidal surgeries, as there is a high incidence of viral shedding. Patients undergoing awake craniotomy should be lightly sedated to avoid an emergent airway, and low-dose lidocaine or remifentanil can be used to minimize coughing. For the endovascular treatment of acute ischemic stroke, a low threshold for gen-

https://doi.org/10.4097/kja.20354

Table 2. Comparison of National Guidelines on the Perioperative Preparation and Management of a Suspected/Confirmed COVID-19 Patients

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
Training	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE; Streaming lectures online	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE	Donning & doffing PPE
Simulation	e.g. Category 1 Caesarean delivery, airway crisis, major hemorrhage	e.g. airway emergency	e.g. Category 1 Caesarean delivery	Intubation/ extubation drills wearing PPE	Possible scenarios and multi-disciplinary teams	Not stated	Not stated	Not stated	e.g. Category 1 Caesarean delivery	e.g. Category 1 Caesarean delivery & airway crisis
Prioritization	Postpone elective surgery. Pandemic surgical framework	Not stated	Postpone elective surgery	Defer elective/ semi-emergency surgery	Not stated	Surgery based on acuity. Postpone elective surgery	Not stated	Not stated	Postpone elective surgery	Postpone elective surgery, surgical review committee
Patient screening	History taking including respiratory symptoms; appropriate triage & prompt isolation of patients	Perform airway assessment with PPE on	Elective cases	History taking (including fever, cough, sore throat and travel history) should be elicited	Not stated	Preoperative screening for acute respiratory illness, pneumonia, contact and travel history, contact with healthcare facility managing COVID-19 patients	Not stated	Not stated	MACOCHA score to predict difficult intubation and prepare strategy	Screen patient for fever, cough, dyspnea, diarrhea & contact history
	Telemedicine for anesthesia consult		History (travel & contact history, respiratory symptoms) & examination	Actively counsel patient to postpone elective surgery						Phone or video assessment for pre-anesthesia encounter
			Referral to infection control if temp > 37.3°C							PCR Testing based on population prevalence
			Emergency cases							
			As above plus Chest Xray or CT							

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Table 2. Continued

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
Resource planning	Team-brief	Not stated	Smaller group to lead airway management in COVID-designated hospitals	Multiple tracheal intubation teams	Team-brief	Team of 5 : 3 in OT and 2 outside as runners	Replace anesthesia team every 2 hours to avoid fatigue	Not stated	Team-brief; Communication checklist; Cognitive aid	Team-brief; Communication checklist
	Smaller group to lead airway management				Standby doctor with donned PPE outside chamber	COVID cart with equipment & drugs			Exclude high-risk staff during airway management	
OT	Negative pressure isolation room	Negative pressure isolation room	Negative pressure isolation room	Designated OT with filters (lack of negative pressure OT) with dedicated anesthesia machine	Negative pressure isolation room	Negative pressure OT	Negative pressure OT	Not stated	Negative pressure OT with > 12 air changes	Designated negative pressure isolation OT
			Warning signs on OT doors	Warning signs on OT doors		Warning signs on OT doors	Warning signs on OT doors		Warning signs on OT doors	Warning signs on OT doors
Patient transfer	To OT with surgical mask	Not stated	To OT with surgical mask	Do not keep patient in holding area	Direct route to OT with surgical mask	Direct route to OT with surgical mask.	Plan ahead for patient transfer.	Not stated	To OT with surgical mask	To OT with surgical mask
						Porters to clear the path	Do not keep patient in holding area		Do not keep patient in holding area	Do not keep patient in holding area
Infection control	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions	Airborne precautions
PPE	N95 mask, face shield or goggles, gown, hat, double gloves for airway procedures	N95 mask or PAPR, face shield or goggles, gown, hat, double gloves	N95 mask or PAPR, face shield or goggles, gown, shoe covers, hood, and double gloves	N95/N99 mask, eye protection, gown, boot covers, hat, double gloves	N95 mask or PAPR device, face shield or goggles, gown, shoe covers, and double gloves	N95 mask, face shield or goggles, gown, shoe covers, and double gloves (PAPR for intubation & extubation)	N95 mask, face shield or goggles, protective coverall/ body suit, shoe covers, and double gloves (PAPR for intubation & extubation)	N95 mask or PAPR device, face shield or goggles, gown, and double gloves	N95 mask, eye protection, gown, double gloves	N95 mask or PAPR device, face shield or goggles, gown, and double gloves
	*PAPR only for trained staff or if performing multiple procedures	Buddy System when donning PPE	Buddy System when donning PPE	Hand hygiene is essential before donning and after doffing PPE	Buddy System when donning PPE	Use "anti-fog" for goggles	Not stated	Buddy System when donning PPE	Buddy System when donning PPE	Buddy System when donning PPE

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https://doi.org/10.4097/kja.20354

Table 2. Continued

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
	Buddy System when donning PPE	Hand hygiene is essential before donning and after doffing PPE	Hand hygiene is essential before donning and after doffing PPE		Hand hygiene is essential before donning and after doffing PPE	Buddy System when donning PPE	Hand hygiene is essential before donning and after doffing PPE	Hand hygiene is essential before donning and after doffing PPE	Hand hygiene is essential before donning and after doffing PPE	Hand hygiene is essential before donning and after doffing PPE
	Hand hygiene is essential before donning and after doffing PPE					Hand hygiene is essential before donning and after doffing PPE				
						Staff to handover all personal belongings to buddy/runner to avoid them becoming fomites				
Equipment	2 viral filters placed in circuit	Hydrophobic/ HEPA filter between circuit & ETT	2 viral filters placed in circuit (between ETT & circuit; & between circuit & machine)	2 viral filters placed in circuit (between ETT & circuit; & between circuit & machine)	Filter placed in circuit	High efficiency Hydrophobic filter on every oxygen interface	HEPA filter between circuit & ETT	HEPA filter between circuit & ETT	HME filter between catheter mount & circuit	HEPA or HME filter between circuit & ETT, gas sampling tubing protected by HEPA filter
	Forced air warming blankets only in intubated patients	Use disposable equipment if possible	Use disposable equipment if possible		Dedicated equipment	Preload closed suction device on anesthesia circuit	Use disposable equipment if possible	Use disposable equipment if possible	Create a COVID-19 tracheal intubation trolley	Use disposable equipment if possible
	Use disposable equipment if possible				Use disposable equipment if possible	Use disposable equipment if possible			Use disposable equipment if possible	

PPE: personal protective equipment, MACOCHA: Mallampati III/IV, sleep apnea, decreased cervical mobility, mouth opening < 3 cm, Coma GCS < 8, severe Hypoxemia, practitioner not an Anesthetist. CT: computed tomography, PCR: polymerase chain reaction, OT: operating theatre, PAPR: powered air-purifying respirator, HEPA: high-efficiency particulate air, ETT: endotracheal tube, HME: heat and moisture exchanger.

Table 3. Comparison of National Guidelines for the Intraoperative Management of a Suspected/Confirmed COVID-19 Patient

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
Anesthesia Technique	Regional technique where possible	Not stated	Regional technique where possible	Regional technique where possible	Not stated	Not stated	Not stated	Not stated	Not stated	Regional technique where possible
Induction	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization	Not stated	Not stated	Limit staff present due to potential aerosolization	Limit staff present due to potential aerosolization
Airway Management	Most experienced clinician	Most experienced clinician	Most experienced clinician	Most experienced clinician	Most experienced clinician	Most experienced clinician	Most experienced clinician	Not stated	Most experienced clinician	Most experienced clinician
Intubation	Use of video- laryngoscope; optimize position	Use of video- laryngoscope	Use of video- laryngoscope (Asleep fiberscope intubation by trained staff)	Use of video- laryngoscope	Use of video- laryngoscope	Use of video- laryngoscope with pre-loaded introducer	Use of video- laryngoscope	Use of video- laryngoscope	Use of video- laryngoscope; optimize position	Use of video- laryngoscope
	Clear plastic cover over patient									
	RSI	RSI	RSI	RSI	RSI	(modified) RSI	RSI	RSI	RSI	RSI
	(Intubation recommended over SAD) Introducer for intubation (stylet/bougie)	Consider induction with Ketamine or use vasopressors in hemodynamic instability							Consider induction with Ketamine or use vasopressors in hemodynamic instability	
	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker	Neuromuscular blocker
	Avoid PPV until ETT cuff inflation. Disconnect mask & HME from circuit to avoid ongoing flow of oxygen out through filter	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation	Not stated	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation	Avoid PPV until ETT cuff inflation
									Ensure tracheal tube cuff pressure ≥ 5 cm-H_2O above peak inspiratory pressure	

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Table 3. Continued

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
Awake fiberoptic intubation	Avoid	Not stated	Avoid	Avoid	Avoid aerosol with topicalization Rescue – Insert SAD if failed 2nd attempt	Not stated	Avoid; Avoid aerosol with topicalization	Avoid	Avoid	Avoid
Difficult Airway	Vortex approach Surgical airway if cannot intubate and oxygenate	Not stated	Not stated	Not stated	Intubate through SAD with flexible endoscope CICO, for early cricothyroidotomy	After failed intubation Plan B: 2nd generation SAD; Plan C: Two-handed mask ventilation Plan D: emergency FONA	Not stated	Not stated	Safe, Accurate, Swift; emergency FONA (Scalpel bougie); Consider intubation via SAD (blind/ bronchoscope assisted)	Not stated
Supraglottic airway device (SAD)	Insert SAD if failed intubation (2nd generation SAD preferred)	SAD for airway rescue	SAD preferred to intubation to minimize coughing at extubation	For airway rescue	Insert SAD if failed intubation (2nd generation SAD preferred)	SAD for airway rescue	For manual ventilation instead of face mask ventilation	SAD for airway rescue	2nd generation SAD preferred. Careful patient selection; controlled ventilation & low peak airway pressures; Intubate if leak is significant	Not stated
Methods of oxygenation	Avoid HFNO; minimize sedation & supplemental oxygen; lung protective ventilation	Avoid HFNO & non-invasive ventilation	Not stated	Avoid high flow oxygen	Use nasal apneic oxygenation 3 L/min Balance risk of viral transmission vs HFNO	Avoid high-flows and extreme positive pressure ventilation	Avoid high flows and HFNO	Avoid HFNO & non-invasive ventilation	Avoid HFNO & non-invasive ventilation	Not stated
Extubation	Closed loop suctioning; Deep extubation, Consider opioids, lidocaine/ Dexmedetomidine SAD exchange to avoid coughing	Prophylactic antiemetics to minimize vomiting	Closed-loop suctioning	Closed-loop suctioning; prophylactic antiemetics to minimize vomiting Cover patient's nose and mouth with wet gauze	Closed-loop suctioning	Consider antiemetics Plastic sheet to reduce droplet dispersion	Not stated	Consider glycopyrrolate or atropine to minimize secretions	Closed-loop suctioning; consider opioids, lidocaine/ dexmedetomidine	Closed-loop suctioning; Prophylactic antiemetics to minimize vomiting and possible viral spread.

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Table 3. Continued

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]	UK [23,24]	US [25–28]
Recovery of patient	Recover in OT; Surgical mask placed over oxygen mask	Not stated	Recover in OT	Patient to wear surgical mask; oxygen mask over surgical mask	Not stated	Recover in OT Surgical mask placed over oxygen mask/nasal prong Ventilators on standby for circuit disconnection	Recover in OT	Not stated	Recover in OT Surgical mask placed over oxygen mask/nasal prong	Recover in OT

RSI: rapid sequence induction, SAD: supraglottic airway device, PPV: positive pressure ventilation, ETT: endotracheal tube, HME: heat and moisture exchanger, CICO: cannot intubate cannot oxygenate, FONA: front of neck access, HFNO: high flow nasal oxygen, OT: operating theatre.

Table 4. Comparison of National Guidelines for the Postoperative Management of a Suspected/ Confirmed COVID-19 Patient

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]
Patient transfer	ICU transfer plan; minimize circuit disconnection; clamp ETT, paralyze before disconnection	Minimize circuit disconnection, clamp ETT	Single-use Ambu bags preferred for intubated patients, avoid ventilator use	Single-use Ambu bag preferred for intubated patients; Use dedicated lift and lobby	Minimize circuit disconnection, clamp ETT; ventilator on standby	Not stated	Not stated	Not stated
Post-operative cleaning & disinfection	OT cleaning as per local protocol Maintain airborne precautions for staff entering OT for at least 30 min	As per hospital terminal cleaning protocol	Environmental disinfection (2–3% hydrogen peroxide spray disinfection, 2–5 g/L chlorine disinfectant/75% alcohol wiping of solid surfaces of equipment & floor)	Environmental disinfection (2–3% hydrogen peroxide, 2–5 g/L chlorine disinfectant/75% alcohol wiping of solid surfaces of equipment & floor)	Not stated	Not stated	Not stated	OT cleaning as per local protocol

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Table 4. Continued

Country	Australia [10,11]	Canada [12,13]	China [14–16]	India [17]	Italy [18,19]	South Africa [20]	South Korea [21]	Taiwan [22]
Post-op handling of equipment	Waste disposal in labelled bins	Waste disposal in labelled bins	Waste disposal in labelled bins (double-bagged)	Waste disposal in labelled bins (double-bagged)	Waste disposal in labelled bins	Dispose all used airway equipment in double zip-locked bag	Dispose all used airway equipment in double zip-lock bag	Dispose all used airway equipment in double zip-lock bag
	Replacement of filters & breathing circuits; seal equipment in zip-lock bag		Replace end-tidal carbon dioxide sample lines & traps				Replace end-tidal carbon dioxide sample lines & traps	
Debriefing	Debriefing post event	Timely feedback, encourage incident reporting	Not stated	Not stated	Debriefing post event	Not stated	Not stated	Not stated
Staff monitoring & welfare	Staff: complete logbook of clinical exposures	Not stated	Daily temperature check: monitor respiratory symptoms and inform occupational med team.	Social distancing measures for staff	Not stated	Not stated	Not stated	Not stated
	Regular communication updates	Wellness resources	May require blood tests and chest CT, consider isolation					Wellness resources on mental health and communicating with empathy
	Consider influenza vaccination							
	Pregnant staff deployed to areas away from COVID-19 patients							
	Wellness resources							

ICU: intensive care unit, ETT: endotracheal tube, OT: operating theatre, CT: computed tomography.

eral anesthesia with intubation by airway personnel in a negative pressure room is preferred over the urgent conversion from sedation [61]. In addition, a lead gown can be worn under the PPE gown [62].

Anesthesia for otolaryngology

For airway surgery such as airway dilatation and tracheostomy, closed-loop communication between the surgeon and anesthesiologist is important to ensure that ventilation is held-off every time the endotracheal cuff is deflated, the tube is removed, or the circuit is disconnected [63].

Trauma anesthesia

Regional anesthesia is recommended where possible. Cricoid pressure during induction of general anesthesia should be used with caution, as it can stimulate coughing. Blood conservation is recommended and thromboprophylaxis should be instituted where possible [38].

Discussion

The strength of this review is that it provides a comprehensive appraisal of all the available guidelines; it also summarizes their strengths and limitations. Our review found that national guidelines for the anesthetic management of COVID-19 patients were moderately comprehensive, but they scored poorly for rigor of development, editorial independence, and applicability. Evidence underpinning guidelines was weak, leading to heterogeneity in recommendations. Gaps in preoperative screening, prioritization for surgery, and anesthesia for specific groups were identified and addressed, albeit with low-quality evidence consisting of retrospective studies, case reports, narrative reviews, and expert opinions.

The Institute of Medicine defines clinical guidelines as "statements that include recommendations, intended to optimize patient care, that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options" [64]. Clinical guidelines assist physicians in providing the best care, and they should adhere to a robust reporting framework. Given the rapid spread of the pandemic, initial guidelines were undoubtedly subjected to time-sensitive pressure in development and publication. As the virus is highly contagious, early guidelines focused on defining aerosol-generating procedures, mitigating aerosolization, and appropriate PPE and infection control practices. These were largely based on retrospective studies and case series during the SARS outbreak in 2003 [30,33,34,42–44]. These initial guidelines have served their purpose in successfully limiting disease spread to healthcare workers. Moving forward, national guidelines should be updated as new data emerge to include the entire perioperative process. Dagens et al. [65] suggested that pandemic guidelines should have transparent timelines for revision and amendment to ensure that they are more robust, especially for the potential viral resurgence. The recommendations should describe how they were derived and indicate their strengths and limitations and whether they were reviewed by experts, including infectious disease physicians and epidemiologists. Importantly, recommendations should be linked to an evaluation of supporting evidence and presented clearly with the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) system [66]. GRADE is widely used by many organizations globally, and it is a transparent and reproducible framework that helps clinicians to understand the underlying logic and principles of the guidelines. The GRADE system comprises a two-level representation of the strength of recommendation (weak or strong) and a four-level representation of the certainty of the evidence (very low, low, moderate, and high) [67]. In addition, conflict of interest, which is essential for any scientific publication, should be disclosed, as many involved experts may have industry affiliations. Non-declaration implies bias, and it reduces the quality and reliability of the recommendations. Contributions from experts in subspecialty interest groups make national guidelines more inclusive and comprehensive. Although attempts to address difficult airway management were addressed by the Difficult Airway Society in the UK and Safe Airway Society in Australia and New Zealand, guidance for other patient groups was scarce.

With countries resuming elective surgeries, gaps in current guidelines would need to be addressed. Of relevance would be preoperative screening, which has important implications for resource utilization, especially PPE, processes, facilities, and manpower. Preoperative screening for COVID-19 and prioritization for surgery is also important, as morbidity and mortality have been reported in pre-symptomatic carriers who have undergone elective surgeries [68]. The USA has proposed two approaches to the perioperative testing of COVID-19 depending on the local prevalence of SARS-CoV-2. The American College of Surgeons recommends that a committee comprising surgeons, anesthesiologists, and nurses (guided by the Elective Surgery Acuity Scale) should assist with the prioritization of patients for surgery [69].

Categorizing COVID-19 to mild, moderate, severe, or critical may also help to refine anesthetic plans [70]. For COVID-19 patients with moderate to severe pneumonia, careful airway assessment is important, as hypoxemia during intubation is common and the options for oxygenation or awake intubation are limited. Critically ill patients with organ dysfunction would require pre-

https://doi.org/10.4097/kja.20354

emptive inotropes, fluid resuscitation, careful titration of drugs, and a lung-protective ventilation strategy [14].

Areas of controversy relating to anesthetic technique, the use of airway devices, the extent of aerosol dispersion, and the management of specific groups require further research and guidance updates as new evidence emerges. Further research on temperature, blood, and fluid management, including the degree of staff surveillance for infection and burnout is also needed.

This review was limited by the language restriction of our search and the quality of evidence available. Evidence was mostly from retrospective studies involving small samples, case reports, narrative reviews, and expert opinions.

Conclusion

National anesthetic guidelines published in the early phase of the COVID-19 pandemic were largely guided by weak evidence, and they lacked robust reporting. As countries move into easing lockdown during the second phase of the pandemic, recommendations need to be updated as new data become available. Guidelines should be subjected to established grading and appraisal systems such as GRADE and AGREE II to provide clarity, especially during a pandemic.

Acknowledgements

Benjamin YL Thong, for assistance with the production of the Tables.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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Supplementary Materials

Supplementary Table 1. AGREE II Instrument [6]
Supplementary Table 2. Combined results from guidelines and database search

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