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Aerosol generating procedures in orthopaedics and recommended protective gear

Nikku Mathew Geevarughese*, Rehan-Ul Haq

Department of Orthopaedics, All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, 462020, India

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ABSTRACT

The prime of COVID-19 forced institutions and hospitals to convert operating rooms into intensive care units. Now as the disease prevalence drops and plateaus in several countries, elective surgeries are being slowly resuming. Such that asymptomatic carriers too would approach hospitals for surgical needs. Coronaviruses are understood to transmit both by droplets and aerosols. Orthopaedic surgery requires regular use of high-speed instruments like power drills, oscillating saws and burrs. Several medical procedures are known to create aerosols thereby exposing the surgeon to contract the virus. Adequate know-how and protective means are mandatory to safeguard the surgical team from inevitable exposure.

1. Introduction

Emerging in December 2019, the severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2) has involved almost all countries and weighs a heavy toll on every nation's healthcare. Elective work had been suspended at several institutions. As restrictions are being eased, elective surgeries are restarting in a phased manner. The role of healthcare providers (HCPs) in patient management is at heightened risks as they are now exposed to both symptomatic and asymptomatic patients in their regular call of duty.

Coughing, sneezing or breathing vigorously create aerosols, usually in the range of 1–5 mm in diameter. Though respirable-size of 1–10 μm is of particular immediate concern, aerosols of 1–5 μm remain in the air.[1] Aerosol-generating procedures are generally defined as a medical procedure which generates aerosols lesser than 10 μm and can travel greater than 2 m.[2] As aerosol are smaller molecules compared to droplets, they travel long distances and therefore are termed as airborne transmission.

Orthopaedic surgery involves quite an amount of aerosol-generating procedures (AGPs). Though AGPs in otolaryngology, neurosurgery, and dentistry are discussed in detail, they have not yet been identified for orthopaedics. Scarcity and scattered information have crippled administrations to derive specifics. We highlight the aerosol-generating procedures encountered in Orthopaedic practice and the minimum personal protective equipment (PPE) imperative in such situations.

2. Presence of SARS-CoV-2 in aerosols

Coronaviruses are identified in blood and other several body fluids. Hence any AGP performed on body tissues generates virus loaded aerosols. The surgical team remains closest to the site of aerosol generation, hence experiences maximum particle density within the operating field, which is always lesser than 2 m.

3. Aerosol-generating procedures

Orthopaedic surgery regularly utilises heavy machinery. Blood and irrigation fluid coming in close contact with high-speed instruments too get aerosolized. AGPs are discussed as high-risk, moderate-risk and low-risk procedures in Table 1.

1. Power drills and high-speed saws - A commonplace in orthopaedic surgery, drills, saws and reamers generate high amounts of aerosols.[3] As these cannot be done with, care must be enforced to prevent the spread of aerosolized particles. Nogler et al. demonstrated that high-speed cutters created a spread area of aerosols upto 6 × 8 metres (the whole operating room) during revision hip arthroplasty.[4]

* Corresponding author.
E-mail address: nikku.mathew@gmail.com (N.M. Geevarughese).

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Abbreviations

AAM	Association for the Advancement of Medical Instrumentation
AGPs	Aerosol generating procedures
CAPRs	Controlled air-purifying respirators
COVID-19	Coronavirus disease-19
FFP	Filtering facepiece
HCPs	Health-care providers
HEPA	High-efficiency particulate air
PAPRs	Powered air-purifying respirators
PPE	Personal protective equipment
SARS-CoV-2	Severe Acute Respiratory Syndrome-related Coronavirus-2

Table 1
Aerosol generating procedures in orthopaedics.

High-risk	1. Power drills, reamers and high-speed saws
	2. High-speed burrs
	3. Pulsed lavage
	4. Electrocauterization
	5. Lasers
Moderate-risk	6. Suctioning
	7. Ultrasonically activated (Harmonic) devices
	8. Heavy instruments like osteotomes, nibblers, gigli saw, hand drills
	9. Arthroscopic/endoscopic procedures
Low-risk	10. Arthrocentesis of tense swellings
	11. Skeletal traction application and removal
	12. Dressings and drain care

2. High-speed burrs - used during tumour resections and laminectomies have been studied. They have shown to create a spread area of 5 × 7 metres around the operating field.[5]
3. Pulsed lavage - Pressured lavage systems regularly used during arthroplasty surgeries and for addressing large contaminated wounds, must be avoided to curtail spurting on the surgical team.[11]
4. Electrocauterization - Regularly used in surgery, electrocautery has been found to create aerosols of < 5 μm both in cutting and coagulation modes.[6] Higher current levels are linked to increased particle aerosolization.
5. Lasers - create smoke which can contain viral particles.[7]
6. Suctioning - has also shown to spread aerosols.[11]
7. Ultrasonically activated devices - like Harmonic scalpel has been shown to generate aerosols of respirable size and spreads beyond 30 cm from the site of production.[4,8]
8. Heavy instruments like osteotomes, nibblers, gigli saw have to be used with extra caution, to avoid splashes on the operating team, and one must preferably avoid using such instruments in an aggressive manner.
9. Endoscopic procedures - There exists a theoretical risk of exposure during laparoscopic procedures, though no confirmed studies have attributed the risks of infection.[1] It is suggested to use constant pressure insulators and central aspirator systems to decrease insufflation and to drain the smoke, respectively. A similar risk can be anticipated during arthroscopic procedures. Similarly, care must be exercised to avoid leaks and prevent waterlogging.

4. PPE for orthopaedic AGPs

Second only to pin-prick injuries, exposure to blood splashes is an important mode of transmission of blood-borne pathogens to HCPs in the pre-COVID-19 season. As orthopaedic surgery deems the use of heavy and sharp instruments, the surgical team is a presumptive target for percutaneous injuries, blood splashes and aerosolized particles. The Centre for Disease Control recommends that "use of a higher level of respiratory protection may be considered for certain aerosol-generating procedures".[9] A detailed description of nuances of specifications of PPE is beyond the scope of this article. Recommended options for PPE in high-, moderate- and low-risk procedures are detailed forthwith, however, they are not an alternative to hand hygiene and personal care (Table 2).

4.1. High- and moderate-risk AGPs

During high-risk AGPs or long duration moderate-risk AGPs, respiratory protection above 95% is preferred. N99/FFP3 respirators provide higher minimum filtration efficiency (99%) to aerosolized particles, compared to the 94–95% by N95/FFP2 respirators.[3,10] Options include N99, R99, P99, N100, R100, P100 respirators, elastomeric respirators with *N*–P 99–100 filters, powered air-purifying respirators (PAPRs), and controlled air-purifying respirators.[7] Fitted goggles are required as face shields are inadequate for eye protection during high-risk AGPs. This is followed by the first layer of surgical gloves, Association for the Advancement of Medical Instrumentation (AAMI)-level 4 (water impermeable) gown with hood covering the neck, knee-high shoe covers and lastly outer gloves.[1] While donning and doffing PPE, it is advised that another HCP assists to ensure the adequacy of the procedure.[10] For long duration AGPs, the use of PAPRs can provide an even higher level of protection and comfort. However, high costs and limited availability restricts its use.

Level 2 PPE precautions are recommended even if the patient tests negative for COVID depending on the local prevalence of the pandemic and possibilities of false negatives. Level 2 PPE includes N95/FFP2 respirators, fitted eye protection, hood covering neck, AAMI level 3 or 4 gown, and double gloves. Sterile procedures in the operating room advocates the use of these PPE in conjunction with a second sterile surgical gown.

4.2. Low-risk AGPs and bedside care

Level 1 PPE including a surgical mask, gloves and face shield or goggles, should be a minimum requirement for low-risk AGPs and

Table 2
Recommended Personal Protective Equipment during aerosol-generating procedures. Adapted from Lammers, Lea and Westerberg 2020.[10]

Recommended Personal Protective Equipment	High- and Moderate-risk AGPs in COVID positive/ suspected[a]	High- and Moderate-risk AGPs in COVID negative[a]	Low-risk AGPs[a] and bedside care
Mask	N99/FFP3, elastomeric respirators with *N*–P 99–100 filters, or PAPRs	N95/FFP2 masks	Surgical mask
Eye protection	Fitted goggles/Face covering PAPRs	Fitted goggles	Face shield/Goggles
Gown	AAMI level 4 with knee-high shoe covers	AAMI level 3 with knee-high shoe covers	AAMI level 2 or 1
Head cover	Hood covering neck	Hood covering neck	(optional)
Gloves	Double gloves	Double gloves	Gloves

[a] When performed in the operating room, a second sterile gown and gloves are mandatory.

routine patient care for all patients. An AAMI level 2 or 1 gown is suggested when there is a probable event of fluid or droplet spread.

4.3. Working with loupes, headlights or microscopes

Orthopaedic subspecialties like hand, microvascular and endoscopic spine surgeons regularly use loupes, headlights and microscopes. Standard respiratory PPE need to be modified in such situations reassuring surgeon safety. Elastomeric respirators can be used with loupes, headlights, and microscopes; however, their fit testing must be ensured.[7]

4.4. Operating room

High- and moderate-risk AGPs should preferably be performed in a negative pressure room with a minimum of 12 air changes per hour, as it prevents dissemination outside the room. The exhaust air is filtered through HEPA filters, which are capable of filtering essentially all particles, including nanoparticles (<0.01 μm).[2] The number of team members exposed should be minimized, movement in and out of the OR limited, only equipment and supplies required for the procedure should be retained in the theatre, and a runner should be stationed outside the OR to attend to additional supplies required.[1,10]

5. Conclusion

The COVID and post-COVID seasons require the surgeon to be extra cautious during operating as s/he can endanger both himself and his team equally. S/he has to be prudent to take overprotective measures in dilemmatic situations to safeguard both the teams' and patient's interests, as prevention is better than cure.

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Declaration of competing interest

The authors have nothing to declare.

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