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Research Letter

Use of powered air-purifying respirators during surgical interventions

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Dear Editor

The COVID-19 pandemic has increased awareness of perioperative aerosolization hazards[1]. Powered air-purifying respirators (PAPRs) provide increased and more consistent protection than surgical masks[2] and other respirators (N95/FFP2–3)[3,4], and have been used empirically in healthcare settings. However, there is a lack of independent evaluation of their appropriateness for surgery, especially in the context of multidisciplinary team interaction. Following satisfactory preclinical, graded user assessment[5], a clinical study (IRB: AEROSOLVE 1/378/2172) was performed for this purpose using a PAPR system (Versaflo™ TR-300; 3M, St Paul, MN, USA) with lightweight full-hood (S-433S).

First, as mandated by local infection control requirements in advance of clinical trialling, the microbiological safety and local airflow impact of the PAPR in the operating room environment was assessed. Settling plate testing was carried out at 10 key operating room positions (including operating table and instrument trolley); team members, wearing either a PAPR or surgical mask, performed predefined particulate-generating actions[6] and simulated surgery (laparoscopic cholecystectomy). Results were compared with those obtained in an empty theatre. Smoke studies evaluated operating room airflow impact around the PAPR–user during baseline and forced expiration with and without concomitant surgical masking. Both studies confirmed PAPR usage compatibility within the acceptable limits for safe surgery, and that surgical masks need not be worn in addition to the PAPR sets.

For the clinical trial itself, after patient and staff consent and donning/doffing instruction, all members of the operating room team (anaesthetists, nurses and surgeons) wore the PAPR in the perioperative period (commencing with anaesthetic induction and continuing to completion of the operation and extubation) during a series of elective general surgery operations of approximately 1 h in duration on COVID-screened patients. Usability was evaluated both subjectively, by validated and previously used questionnaires[5], and objectively, through independent observation. Twenty-five users fully completed the trial over five operations (2 laparoscopic cholecystectomies, 2 open repairs of inguinal hernia and 1 ileostomy reversal), with none having had previous clinical experience of working in a PAPR. All procedures were performed satisfactorily within reasonable time frames (both by phase and overall), with no rejection of the PAPR or sterility breach. Mean usability scores, overall and by role (*Table 1*), were acceptable, with only listening effort differing significantly by group (surgeons suffered most impact: $P = 0.024$ (Kruskal–Wallis test), $P = 0.017$ and $P = 0.022$ (Mann–Whitney U test) *versus* anaesthetists and nurses respectively). Narrative feedback provided insights regarding visual (loss of peripheral vision with episodic obstruction of the assistant's view by the primary operator) and auditory (disorientation and fan-noise distraction) impairment, nuisance thermal sensation (increasing over time), concern over head clearance (for instance between surgeons and theatre lights), and some feeling detachment ('watching through a screen'). Interestingly, when comparing these results with the previous preclinical full-hood team simulations using the same assessment methodology[5], breathing effort perception diminished significantly (mean(s.d.) score 1.36(0.50) *versus* 1.12(0.44); $P = 0.043$, Mann–Whitney U test), whereas ease of communication scores improved significantly (1.43(0.51) *versus* 2.00(0.50); $P = 0.002$).

Overall, PAPRs were usable with care and some compromise during surgery although scope exists for further technical optimization, especially to aid communication and accommodate specific tasks (such as stethoscopy). The lighter, more advanced PAPR set used in this study performed better than that tested previously, including with regard to pump alarming and tubing collisions, and also obviated the requirement for concomitant standard surgical masks. The absence of an approved cleaning protocol and the lack of robustness of the hood-frame indicate a single-use policy for the headsets and tubing, undermining potential cost–benefit averaging over multiple cases. Although there remains some concern for procedures of longer duration or greater complexity (including emergency cases), user acclimatization and application in operations for COVID-19-infected patients (when the respiratory protection benefits may be more appreciated) may offset PAPR constraints.

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Table 1 Mean user assessment scores, overall and by team member role

Measured score	Clinical score overall and by role					Preclinical comparison score[5]	
	Overall ($n = 25$)	Surgeons ($n = 10$)	Anaesthetists ($n = 5$)	Nurses ($n = 10$)	*P* (inter-role comparison)*	Team simulation with full hoods ($n = 14$)	*P* (comparison *versus* clinical score)†
Thermal sensation: −3 (hot) to +3 (cold)	−0.04(1.10)	−0.30(1.34)	0.40(0.55)	0.00(1.05)	0.440	−0.64(0.93)	0.075
4-Point thermal comfort: 1 (comfortable) to 4 (very uncomfortable)	1.12(1.20)	0.80(1.75)	1.20(0.45)	1.40(0.70)	0.577	1.14(0.36)	0.789
Perception of breathing: 1 (not noticeable) to 7 (intolerable)	1.12(0.44)	1.30(0.67)	1.00(0.00)	1.00(0.00)	0.210	1.36(0.50)	0.043
Borg rating of perceived exertion: 6 (no exertion at all) to 20 (maximal exertion)	7.14(1.99)	7.70(2.54)	6.70(0.97)	6.80(1.75)	0.623	8.11(2.29)	0.135
Eye dryness: −3 (very dry) to +3 (very wet)	−0.20(0.50)	0.00(0.00)	−0.20(0.45)	−0.40(0.70)	0.189	−0.57(0.94)	0.146
Ease of communication: 0 (impossible) to 4 (easier than normal)	2.00(0.50)	1.90(0.57)	1.80(0.45)	2.20(0.42)	0.247	1.43(0.51)	0.002
Listening effort: 0 (no meaning understood with any feasible effort) to 4 (no effort required)	1.76(0.93)	1.20(0.42)	2.40(1.14)	2.00(0.94)	0.024	1.71(0.73)	0.899

Values are mean(s.d.).
* Kruskal–Wallis test;
† Mann–Whitney *U* test.

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