


Is the use of a powered dermatome an aerosol-generating procedure (AGP)? Implications for personal protection against COVID-19 virus

Scars, Burns & Healing
Volume 6: 1–7
DOI: 10.1177/2059513120951920
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Kayvan Shokrollahi , Ioannis Kyriazidis, Shomari Zak-Williams, Claire Jones, Elisa Murgatroyd and Dilnath Gurusinghe

Abstract

Introduction: Many healthcare workers have contracted SARS-CoV-2 during the pandemic, many cases of which have resulted in severe illness and death. No studies have assessed the potential for powered dermatomes to generate aerosol, an essential technique in burns and plastic surgery. The primary aim of the present study was to capture video footage to illustrate the potential for a powered dermatome to generate significant spray and hence aerosol.

Methods: We utilised a simulated skin graft harvest experimental method. Fluorescein-stained saline was used with ultraviolet (UV) backlighting to demonstrate fluorescent spray from a popular brand of air-powered dermatome. Ultra-slow-motion (960 frames/s) video was used to demonstrate the oscillation of the dermatome blade and the origin within the machine of any spray generated, and the extent of spray generated.

Results: The key finding from this study is the captured video footage linked with this paper. Droplets of various sizes are seen spraying out from the leading edge at the sides where the blade oscillates. UV backlighting provides a clear demonstration of the dermatome generating fine spray.

Conclusion: Our study demonstrates that powered dermatome usage is likely to generate aerosol from blood or blood-contaminated fluid, but does not demonstrate or quantify to what extent this may be clinically relevant in terms of viral transmission potential. We suggest ways to reduce the risk of spray from dermatomes including limiting donor-site bleeding and avoiding a wet donor area.

Keywords

Dermatome, COVID-19, coronavirus, aerosol, personal protective equipment, aerosol-generating procedure, split skin graft, plastic surgery

Mersey Regional Centre for Burns and Plastic Surgery, Whiston Hospital, Prescot, Merseyside, UK

Corresponding author:

Kayvan Shokrollahi, Mersey Regional Centre for Burns and Plastic Surgery, Whiston Hospital, Warrington Rd, Prescot, Merseyside L35 5DR, UK.
Email: kayvan.shokrollahi@sthk.nhs.uk

Hyperlinks to the videos have been added on pages 4 & 5 after the article was published online



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Lay Summary

A dermatome is a device used by surgeons to harvest split skin grafts (SSGs). SSGs are an essential component of burns and reconstructive plastic surgery. Aerosol-generating procedures (AGPs) have implications for transmission of viruses including COVID-19. It has not previously been formally assessed whether use of a dermatome should be classified as an AGP. This study uses a fluorescent dye in the context of simulated surgery using a dermatome to see if any, and how much, fine spray is generated from the device and also utilises ultra-slow-motion videography to see how any spray may be generated. At the heart of this study is the included video footage that demonstrates considerable fine spray generation which suggests it is best to assume that dermatomes are likely to generate some degree of aerosol depending on the clinical scenario and how it is used. However, this information does not translate to providing any information about the risk of transmission of the virus from using a dermatome, especially in relation to COVID-19, and separate research would be required to answer this.

Introduction

On 11 March 2020, the World Health Organization (WHO) characterised the COVID-19 disease caused by a novel coronavirus (SARS-CoV-2) capable of severe acute respiratory syndrome (SARS) as a pandemic.¹ Given the fact that an average operating theatre would see over 1200 procedures per year, and that 18% of them are for patients requiring emergency surgery,² thousands of patients positive for COVID-19 are likely to require surgical interventions during this outbreak. Furthermore, a study recently published in *The Lancet* concluded:

‘Postoperative pulmonary complications occur in half of patients with perioperative SARS-CoV-2 infection and are associated with high mortality. Thresholds for surgery during the COVID-19 pandemic should be higher than during normal practice. . .’³

As demonstrated by Weber et al.,⁴ despite well-established safety protocols, healthcare professionals are at continuous risk from occupational infectious disease transmission from patients. Many frontline healthcare workers had a significantly increased risk of contracting the SARS-CoV-2 virus during the outbreak, numerous cases of which resulted in severe illness and death.⁵ Despite the significance attributed to the management of patients with acute respiratory disease, and the existence of guidelines and protective measures for these cases, the degree of transmission risk associated with aerosol-generating procedures (AGPs) is not yet clear.^{6,7} A more recent systematic review⁸ identified some procedures to present an increased risk of transmission. These included tracheal intubation, non-invasive ventilation, tracheotomy and manual ventilation before intubation; other intubation-associated procedures, endotracheal aspiration, suction of

body fluids, bronchoscopy, nebuliser treatment, administration of O₂, high flow O₂, manipulation of O₂ mask or BiPAP mask, defibrillation, chest compressions, insertion of nasogastric tube and collection of sputum were not significant.⁸ Viral RNA has been detected in faeces,^{9–11} whole blood,^{9,12–14} serum,^{15,16} saliva,^{15,16} oro/nasopharyngeal specimens,^{9,17} urine,⁹ ocular secretions,¹⁸ breastmilk,¹⁹ and in placental or fetal membrane samples.²⁰ Substantial further research is required in relation to the degree of infectivity from a number of these additional sources of viable virus. Nevertheless, the potential to aerosolise any virus-laden fluid will expose surgical teams to SARS-CoV-2, the subsequent risk of infection from which is currently unknown.

AGPs have been identified from several surgical procedures, including those that use electrocautery and high-speed tools,^{21–23} and smoke from electrocautery has been shown to harbour intact bacterial and virus particles.^{22,23} Thus, surgical procedures utilising certain devices can be considered potential AGPs,^{21–24} and the absence of specific studies on individual devices has led to ‘best available’ comparisons to be made, which can be tenuous. Lasers can also create virus- and bacteria-laden plumes.²⁵ It is clear that the evidence for the creation of aerosols associated with these procedures, the burden of potential viable microbes within the created aerosols, and the mechanism of transmission to the host have not been well studied. Professional bodies, such as the British Burn Association (BBA) and British Association of Plastic Reconstructive & Aesthetic Surgeons (BAPRAS),^{26,27} have either issued guidance or have received requests for clarifications that are relevant to the appropriate personal protective equipment (PPE) in a range of scenarios.

Split thickness skin grafts (STSGs) are a widely used reconstructive option in the field of burns and reconstructive plastic surgery. STSGs

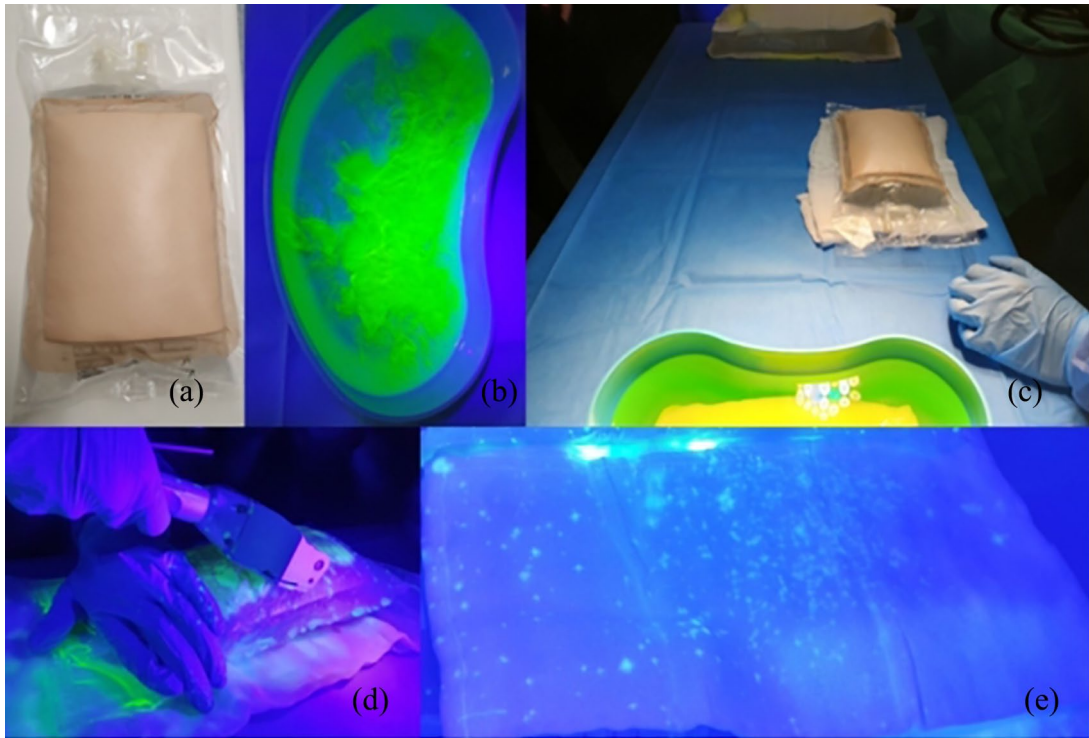


Figure 1. Experimental setup. From left to right and clockwise: (a) An unopened bag of saline with adhesive dressing to simulate donor site; (b) fluorescein-stained saline with ultraviolet light backlight to simulate a donor site wet with blood or fluid; (c) simulated operating environment; (d) powered dermatome in use; (e) fluorescein-tinted spray from dermatome captured on dry gauze. Readers are referred to the videos which are the focus of this study.

may be harvested in a variety of ways.²⁸ The most commonly used technique involves a dermatome, which provides rapid, consistent harvest of large uniform-thickness grafts. Dermatomes are typically air-powered or electric, although manually operated devices exist. All powered dermatomes harvest with a rapidly oscillating blade. Despite STSGs being a major tool in a surgeon's quiver for reconstruction of burns and skin defects, there is no study that examines their potential harvest as an AGP. The most detailed review of the evidence to date^{29,30} does not mention dermatomes, but does acknowledge indirectly that power tools may be AGPs. Thus far, the plastic surgery community has only had limited indirect evidence such as this from which to make key decisions. The present study seeks to establish directly whether powered dermatome usage has the potential to be an AGP, and to put this in clinical context based on the current world literature.

Methods

In this experimental study, we undertook a simulated skin graft harvest and utilised both

standard and ultra-slow-motion (960 frames/s [FPS]) filming to provide further information regarding the potential for an air-powered dermatome. Capturing the video footage and making this available to the readership was the focus of this study. In addition, we have interpreted and put the captured video footage into context.

The setup is demonstrated in Figure 1. The details of the simulation were as follows:

1. A bag of saline with adhesive foam simulated a skin graft donor site. Such models are commonly used in teaching courses to simulate skin graft harvest.
2. Fluorescein-stained saline was used to wet the surface to simulate a wet, bloodied or blood-stained and/or lubricated donor area.
3. Ultraviolet (UV) light-emitting diode (LED) torches and a UV bulb were used as a backlight to demonstrate the fluorescent spray and its distribution in a striking and highly visible manner.
4. Simulated skin graft harvest was undertaken using a popular brand of air-powered

dermatome (Zimmer Biomet UK Ltd.) set at 0.1 inch/0.25 mm.

5. Standard and ultra-slow-motion filming was undertaken, in addition to high-resolution photographs, to demonstrate the oscillation of the dermatome blade and the origin within the machine of any spray generated.

Results

The key finding from this study is the captured video footage linked with this paper

Ultra-slow-motion video at 960 FPS was captured during usage of a powered dermatome. Droplets of various sizes spraying out from the leading edge at the sides where the blade oscillates are clearly visible (Supplemental Material – Video 1).

The real-time video with UV backlighting provides a very clear demonstration of the dermatome generating various sizes of fine droplets that change a clean swab to one coated in fine spray (Supplemental Material – Video 2) across its entire length and breadth. The spray emerges from the leading edge of the dermatome backwards at an approximate angle of 45°.

Discussion

Due to the COVID-19 pandemic, there has been an urgent requirement to determine the occupational risk of various procedures and interventions so that these can be accommodated by a range of local, national and international guidelines and policies based on whether they are AGPs. The available guidance includes the 2014 WHO guidelines published before the COVID-19 pandemic,³¹ as well as other guidance that has emerged since then.³² Surgical specialty professional bodies have either issued guidance or have received requests for clarifications that are relevant to the appropriate PPE in a range of scenarios. However, one unknown at present relates to powered dermatomes and whether they should be treated as potentially aerosol-generating. A recent consensus opinion has been formulated by the BBA²⁶ that in the absence of scientific evidence it is likely that procedures utilising powered dermatomes are AGPs when navigating relevant PPE guidelines. This guidance has been underscored by BAPRAS, who have issued guidance as follows:

‘Plastic Surgery Specific devices: in the absence of firm safety evidence on aerosol generation, use of powered tools (including high speed drills, dermatomes and

high-pressure irrigation/debridement devices) should be avoided, if clinically safe.’²⁷

It has been acknowledged that no published evidence exists thus far on dermatomes. Furthermore, while most evidence suggests the highest risk of viral transmission comes from airways and mucosal surfaces, especially procedures above the clavicle, studies have confirmed the presence of the virus in numerous other body fluids including the blood.^{9–14} While Health Protection Scotland has assimilated the world literature on AGP-related guidance into a useful summary,^{29,30} it does not mention dermatomes.

Dermatome usage has therefore not been formally categorised as an AGP, although the abovementioned consensus and other opinions have been expressed in this regard. Some pre-COVID-19 studies have shown aerosolisation from use of both drilling machinery in the operating room and ultrasonic dental devices,^{21,22} which lends credence to the potential for similar equipment such as dermatomes and hydro-debridement tools to also generate aerosols, but this is an indirect extrapolation. Certainly, the dermatome is not on any list such as the WHO list of AGPs published in 2014³⁰ or in the World Federation of Anaesthesiologists’ list.³¹ There is, however, an advisory suggestion by BAPRAS and the BBA in relation to dermatome usage and its potential to generate aerosols.^{26,27} This study suggests dermatome usage is likely to be an AGP, but does not provide any information with regards to clinical context and what degree of risk usage is likely to confer in relation to COVID-19. While previously cited studies show the presence of the virus in many bodily fluids, only a minority of individuals in the *Lancet Infectious Disease* study had viremia,¹⁴ and the most likely source of aerosolised virus from a skin donor site is likely to be from blood. However, it must be noted that skin graft donor sites for major burns will sometimes come from areas that could be contaminated with other bodily fluids. This includes the scalp donor site, which could be contaminated with ocular secretions and from the oro/nasopharynx, and buttock donor sites, which could be contaminated with faeces, especially when faecal tubes are in situ. It is unclear as to whether sweat may harbour the virus.

Our experiment has provided video footage that can be appraised by the readership and which provides a platform for further discussion and further research. In our analysis, the video footage (supplemental material) demonstrates the fine spray that can potentially be caused by

the powered dermatome and the visible distance that this spray travels. Furthermore, the ultra-slow-motion video (supplemental material) demonstrates the generation of fine droplets; it is the first time that a dermatome has been filmed in ultra-slow motion demonstrating this phenomenon.

The amount of fine spray created by a powered dermatome in this simulation justifies the assertion that it is likely, or at least possible, that powered dermatome usage generates some degree of aerosol from blood or blood-contaminated fluid beyond simply droplets, but does not demonstrate or quantify to what extent nor whether this is clinically relevant in terms of transmission. It is likely that the finer and less visible spray will travel an even greater distance than the visible distance demonstrated in the images or videos and will need to be evaluated by more sophisticated means. While the evidence is circumstantial, it remains the first-available and best-available evidence in the published world literature. It must be noted that while the potential to aerosolise any virus-laden fluid may put surgical teams at risk of *exposure* to SARS-CoV-2, the subsequent risk of *transmission* from any such exposure is currently unknown. We know that the detection of viral RNA by polymerase chain reaction (PCR) does not equate with the potential for infection unless infectious virus particles have been confirmed through virus isolation and culture; furthermore, correlation has been suggested between the isolation of viable virus and the initial viral load.³³ Hence, further studies are required to put the results of this study into clearer clinical context.

This study therefore underscores the position that it is reasonable with the current evidence to categorise dermatome usage as an AGP, and hence to maintain PPE for procedures utilising a dermatome on that basis. Future work could refine or even challenge this view.

Having demonstrated the likely AGP status of dermatome usage, we have reflected on our experiment and hypothesise how dermatome usage might be made safer by reducing bleeding from the harvest site and reducing fluid available to create spray. Surgical teams do have the potential to modulate the skin harvesting environment in certain ways. Common sense measures would include pre-infiltration with local anaesthetic solution containing adrenaline which would likely reduce bleeding from a donor site at the advancing edge of the dermatome. Similarly, avoidance of saline and

a wet environment in favour of paraffin for lubrication to allow glide of the dermatome may limit the potential for blood-contaminated fluid to enter the dermatome and generate potentially hazardous spray.

Conclusion

Based on real-time and ultra-slow-motion video footage of a powered dermatome in use during simulated SSG harvest, we believe powered dermatomes are likely to generate aerosol from any fluid, including blood present at the blade interface. Hence, dermatome use should be categorised as an AGP. It should be noted that our study provides no information on the risk of transmission of COVID-19 through this practice, and it is uncertain how dermatome use may translate into clinical risk when compared with other procedures currently defined as AGPs that originate from airways and mucosal surfaces. Decisions relating to PPE for procedures requiring dermatome usage should take into account our findings.

It is likely that the creation of spray from dermatomes can be reduced with less water, fluid or blood in the operative field, and the surgical team do have the potential to modulate this harvesting environment by use of paraffin to lubricate the area of harvest (instead of water or saline), and infiltration of the donor site with local anaesthetic with adrenaline to limit bleeding – the simple assertion being ‘less wet, less blood, less spray’.

There is a need for further studies to ascertain the aerosol-generating nature, and hence risk of COVID-19 transmission, of a range of interventions relevant to burns and plastic surgery, including those listed in the BAPRAS guidance.²⁷ The methodology we employed in this study may be helpful in this regard, at least for preliminary experimental studies on other devices. It can also be envisaged that a modification of this strategy could easily be adapted for use *in vivo*.


Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Kayvan Shokrollahi  <https://orcid.org/0000-0003-1044-7781>

Supplemental material

Supplemental material for this article is available online.

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How to cite this article

Shokrollahi K, Kyriazidis I, Zak-Williams S, Jones C, Murgatroyd E and Gurusinge D. Is the use of a powered dermatome an aerosol-generating procedure (AGP)? Implications for personal protection against COVID-19 virus. *Scars, Burns & Healing*. Volume 6, 2020. DOI: 10.1177/2059513118915920.