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ORIGINAL STUDY

A quantitative assessment of facial protection systems in elective hip arthroplasty

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Study performed at Merlin Park Hospital, Galway, Ireland

We aimed to assess the risk to surgeons of blood splatter during total hip arthroplasty.
Hoods from personal protection systems used in 34 consecutive total hip replacements were collected and the area of blood splatter was measured and compared to goggles and visors.
Thirty one primary THA's (13 cemented, 4 hybrid, 14 uncemented) and 3 revisions (1 hybrid, 2 uncemented) were collected. Splashes were detected on all of the masks with a mean of 0.34% cover. Splatter was greatest for the operating surgeon, followed by the first assistant, though the difference was not statistically significant. Operating personnel were at greater risk of contamination during uncemented arthroplasty ($p < 0.0001$; 95% CI). On average 50.60% and 45.40% of blood cover was outside the area protected by goggles and visors respectively. There was a significant difference between the Personal Protection Systems (PPS) and goggles ($p = 0.0231$; 95% CI) as well as between the PPS and visors ($p = 0.0293$; 95% CI).

Keywords : blood splatter ; facial protection.

INTRODUCTION

Blood splatter is a concern to surgeons across the subspecialties and there is a realistic possibility that disease may be transmitted via ocular contamination with Hepatits B (*2*) or Hepatitis C (*5*) infected blood. The amount of blood that could potentially land in the surgeon's eyes is often underestimated (*4,6*). Unfortunately eye protection is commonly uncomfortable to wear and often subject to 'misting', therefore it is often neglected.

The risk of ocular inoculation is particularly high in the field of orthopaedics. Blood in the operating field is easily splattered towards the eyes of the operating team by power instrumentation and lavage, and the volume of potentially infectious material is increased with the liberal use of irrigation required to minimize the risk of prosthetic infection. Preventing these splashes by covering the wound with gauzes during femoral and acetabular component insertion can help save the eyes of surgeons, but prevents observation of the implant, and therefore the position of the implant cannot be assured.

Personal Protection Systems (PPS, Fig. 1) are an evolution of the Total Body Exhaust suits designed

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Fig. 1. — The Stryker T5 Hood

and pioneered by John Charnley *(3)* in Wrightington. We use the Stryker T5 system, which is lightweight and has no hose connection allowing the surgeon relatively unlimited mobility. The fan in the helmet is designed to bring air in from outside the hood (from the surgeons back) and force this down the inside of the face shield and out through the bottom of the surgeons gown, thus creating another laminar flow environment inside the surgeons own operating clothing. We introduced the system to our hospital in order to help combat infection rates in joint arthroplasty *(1)* ; however there is a protective aspect to these suits that is often unappreciated *(7)*.

We aimed to assess the amount of masks with blood splatter on the visor, measure the area of these blood splashes, compare various levels of blood splatter in different groups (implant type and surgeon position) and compare the protection of the T5 hood to two alternative methods of eye protection.

MATERIALS AND METHODS

Over a three-month period PPS hoods were collected from 34 elective hip arthroplasties (one from each surgeon, a total of 102 masks). All operations were performed using a modified Hardinge approach (patient in the lateral position with the operating surgeon on the dorsal side of the patient, the1^{st} assistant on the ventral side caudal to the 2^{nd} assistant, also on the ventral side) with the use of pulsatile lavage and power instrumentation in all cases.

The transparent plastic "visor" section of the hood was scanned into a computer using an Epson Precision 2580 scanner (Seiko Epson Corporation, 3-3-5 Owa, Suwa, Nagano) at 800dpi. The images were resized to 1024×1280 pixels with a Lancos resize filter to allow for easier analysis (Fig. 2a). Contrast adjustment was performed using IrfanView 4.27 (Irfan Skiljan Postfach 48, 2700 Wiener Neustadt, Austria) using standardised levels, and the images were analysed using ImageJ 1.43 (Rasband, W.S., ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA, http://rsb.info.nih.gov/ij/) with the inbuilt threshold (Fig. 2b) and particle detection (Fig. 2c) functions. It should be noted that the particle detection function outlines the detected particles with a ring, therefore relatively small particles (even one pixel in size) are highlighted and visible, this gives the appearance of larger particles being detected (as in Fig. 2c). Though this process makes it simple to see what the program is


a


c

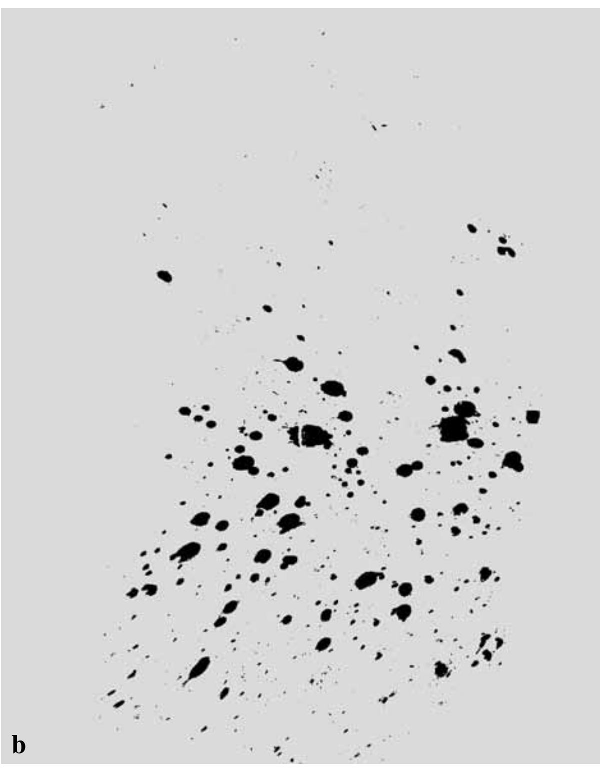

b

Fig. 2. — Image analysis with ImageJ
(a) Original Image ; (b) A threshold conversion of the original image that is used to identify particles ; (c) Particle analysis whereby the number and size of particles is measured by the analysis software.

actually doing the area measured is that of the original particles, not the area of the highlighting procedure.

Percentage cover was calculated using the number of "blood" pixels as a percentage of the total image pixels (1024*1280 = 1310720) and statistical analysis was performed with StatsDirect 2.5.6 (StatsDirect Ltd,11 Gresham Way, Sale, Cheshire, M33 3UY, UK) using the Wilcoxon Signed Ranks and Mann-Whitney U tests, as well as ANOVA. All statistics were performed on raw pixel numbers.

An estimation of the blood splatter that would have fallen outside of the area of protection of traditional methods of facial protection was performed. This analysis was undertaken using a subtraction mask to simulate the area of protection provided by a visor or goggles (Fig. 3). When performing digital subtraction a "mask" is overlaid onto an image and this mask instructs the computer how to show the image. The mask is an image of identical size with areas of black and white which is placed on top of the image to be masked, anything

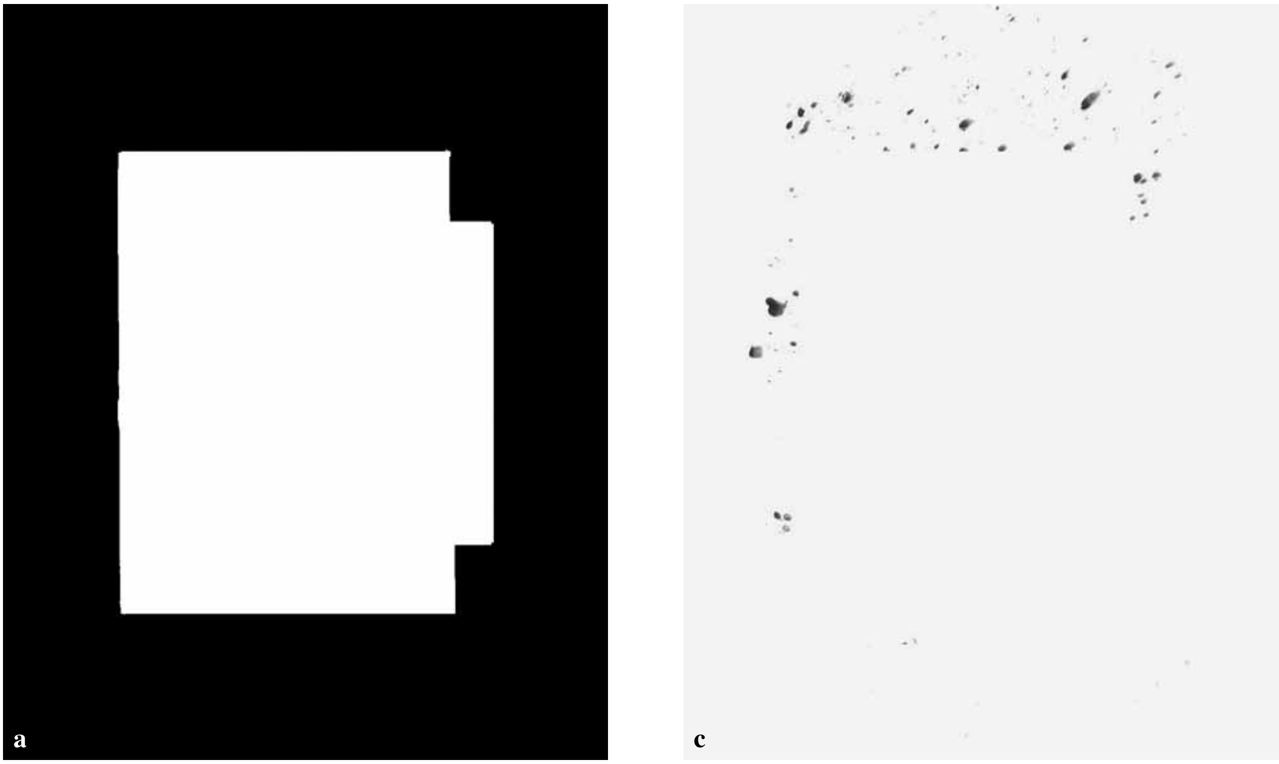
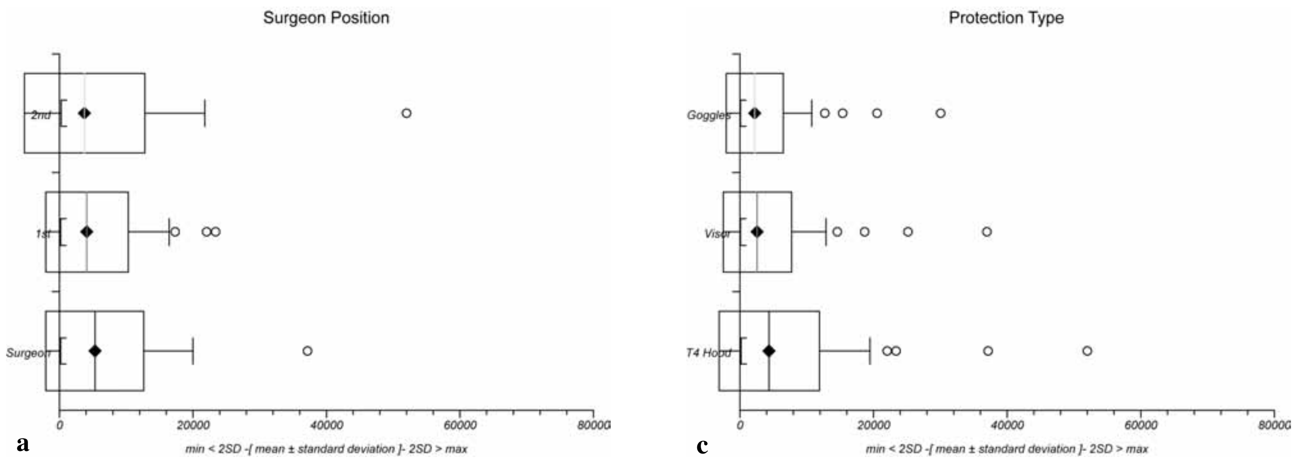


Fig. 3. — Image analysis after digital subtraction mask (1 = visor, 2 = goggles).
(a) Digital masks that are overlayed onto the original images ;
(b) Resultant image following digital subtraction masking ;
(c) The threshold of resultant image for use in particle analysis.

"under" the white areas are preserved (as they show through the mask) and anything under the black part of the mask is ignored. This method gives us an impression of what blood splatter is left outside of the area protected by goggles or masks, and therefore allows us to draw conclusions about the risk of splatter when using another form of eye protection.

RESULTS

Of the 34 hip replacements performed, 31 were primary (13 cemented, 4 hybrid with uncemented acetabula, 14 uncemented) and 3 were revisions (1 hybrid with an uncemented acetabulum, 2 uncemented). Due to the low numbers of hybrid arthroplasty, these were treated as uncemented arthroplasties as it was generally felt that most blood splatter in uncemented cases occured during



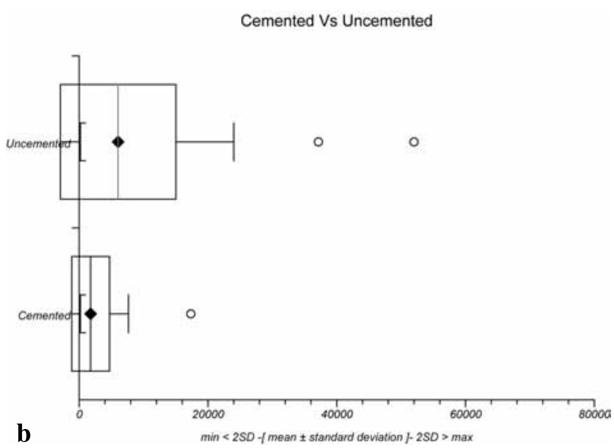


Fig. 4. — Box & whisker plots of variables.
(a) Surgeon position ; (b) Implant type ; (c) Form of eye protection.

implantation of the acetabular component. Revision arthroplasty was not analysed separately to primary arthroplasty as numbers were insufficient to perform statistical analysis.

Splashes were detected on all of the masks with an average of 0.34% (SD = 0.58) cover, a minimum of 0.01% cover (surgeon in primary cemented) and maximum of 3.97% cover (2^{nd} assistant in a primary hybrid).

Risk of contamination was the greatest for the operating surgeon (5317.41 pixels ; 0.41%), followed by the first assistant (4117.68 pixels ; 0.31%), then the second assistant (3764.15 pixels ; 0.29%) see figure 4(a). There was significant difference between the surgeon and the 2^{nd} assistant ($p = 0.445$), however there was no significance to the differences between surgeon and 1^{st} assistant ($p = 0.270$) and the 1^{st} and 2^{nd} assistant ($p = 0.566$) with Wilcoxon signed ranks test (95% confidence interval).

Operating personnel were at greater risk of contamination during uncemented arthroplasty (0.77% cover) when compared to cemented arthroplasty (0.23% cover). This was shown to be significant using the Mann-Whitney U Test ($p < 0.0001$; 95% CI) see figure 4(b).

The results of our extrapolation, namely those from digital subtraction of the images, showed that on average 50.60% and 45.40% of splash area was outside the area protected by goggles and visors respectively. ANOVA analysis (Newman-Keuls) showed that there was a significant difference between the PPS and goggles ($p = 0.0231$; 95% CI) as well as between the PPS and visors ($p = 0.0293$; 95% CI). The difference between visors and goggles was not significant ($p = 0.6473$; 95% CI) see Fig. 4(c).

DISCUSSION

It is our duty as surgeons to protect ourselves from the potential of infection by the blood borne pathogens that our patients may be infected with. Unfortunately current methods of eye protection in particular are cumbersome, and are therefore commonly removed during a procedure (due to poor vision caused by misting) or, more seriously, neglected altogether. Since the adoption of the PPS in our unit, compliance has been high. The main advantage is the inbuilt fan which prevents fogging of the plastic visor.

We have shown that every procedure caused splash contamination of every member of the surgical team, that could potentially land on the face. This is in agreement with the literature, Sharma *et al* (8) found blood splashes on approximately half of surgeons' goggles, and one-third of assistants' goggles. Marasco *et al* (6) found 44% of goggles became contaminated, only 8% of which were recognized during the procedure. Collins *et al* (4) found blood on 86% of goggles, only 15% of which was recognized at the time of operation. Although our study does not really differentiate very well between particles caused by blood splashes and those as a result of the pulsatile lavage mist, we feel that the difference is relatively academic, as both types of splatter could transmit blood borne infections.

Some of our results are unsurprising ; naturally the operating surgeon would be at greatest risk as he is closest to the operating field with a direct line of vision to the source of blood splatter. It is also expected that the uncemented arthroplasty would be associated with greater blood splatter due to the nature of the procedure, the rhythmic force produced by mallet blows when implanting an uncemented prosthesis is the perfect 'pump' for splattering of blood. More surprising is just how much blood is outside the area protected by the alternative methods of face protection. Though these are extrapolated results and therefore not completely reliable, we feel that they are close enough to represent a real potential of contamination of the surgeon who would normally feel safe whilst wearing them. There is naturally a feeling of security whilst wearing the protective systems, and a possible neglect of splash prevention whilst protected by them. However this absolute protection means that the surgeon's attention is more focused on the operation rather than the protection of his face.

In conclusion we would have no hesitation in recommending that surgical protection systems should be used in all elective arthroplasty, and currently we are assessing the benefit of introducing it to our trauma service as a protective measure.

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