Analysis Of Surgical Irrigants In High-Pressure Paint Injection Injuries As Determined By Fluorescent Particle Imagery

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INTRODUCTION: High-Pressure Paint Injection Injuries (HPPIIs) are serious medical emergencies caused by the accidental injection of latex or oil-based paint at a high-pressure from an industrial sprayer into the soft tissues of the hand. The high-pressure injection, caustic effects of the paint, and secondary cellular reactions result in high levels of patient pain, inflammation, and eventual necrosis of the surrounding tissue within the hand. The current standard of care in treatment is emergent surgical decompression with saline irrigation and debridement as soon as possible. Even with surgery, there is a high rate of patient morbidity and secondary amputation. When choosing an irrigant, there is a paucity of literature on the ideal irrigation fluid for surgical removal of oil and latex based paints from human tissue. This study aims to evaluate the effectiveness of various approved hospital-grade irrigation fluids in the removal of oil and latex paints using a cadaveric model of a HPPII. We hypothesize that the irrigant containing a large number of surfactant molecules will result in the greatest amount of paint to be removed, regardless of paint type.

METHODS: The fingers and thumbs from seven human cadaveric hands (two female, five male) were disarticulated at the metacarpal joint and divided into two sets. Each set, latex and oil based, consisted of four groups with four digits each. Specimens from each group were injected with 0.8mL of fluorescent paint into the fat pad on the volar fingertip by means of a 10 ml syringe to simulate a HPPII. After 1 hour, a central, volar, longitudinal incision was made from the most distal end of the distal phalanx to the second interphalangeal joint. Skin flaps were tied back with a 2-0 nylon suture in order to expose the involved soft tissues. Next, the incised finger was fixed to a platform and frame apparatus outfitted with stationary UV lights and a mounted digital camera in standardized fashion across all trials (Figure 1). The specimens were then photographed under the UV light before and after scrubbing using the same camera settings. Each specimen was scrubbed with 50mL of one of four different irrigant formulations: saline, ethanol/acetic acid (Bactisure, Next Science Ltd), surfactant containing (Biasurge, Sanara MedTech) or castile soap. Specimens were scrubbed for four 30 second increments for a total of 120 seconds. Consistent scrubbing pressure was maintained across specimens and trials by a custom-built spring-loaded trolley with an attached surgical prep sponge (Figure 1). Mean intensity was used as the measure of amount of paint within the specimen's soft tissue. To determine the amount of paint removed by the irrigant in each trial, the before and after photos from a constant and standardized injury zone were analyzed using FIJI scientific imaging software.

RESULTS: Significant differences were found between the irrigation solutions when applied to latex paint injuries (Figure 2). The difference in fluorescent intensity after scrubbing with saline was 17.41 ±1.01, which was significantly less than the intensity difference after using castile soap (38.01 ±4.08, p=0.026) and the surfactant containing formulation (39.94 ±2.7, p=0.014). The was no difference when the ethanol/acetic acid formulation (31.36 ±6.62) was compared to saline (p=0.209).

Significant differences were also found when the irrigation solutions were applied to oil-based paint injures (Figure 3). The difference in fluorescent intensity after scrubbing with saline was 44.31 ±1.72 which was significantly less than when the ethanol acetic acid formulation was used (60.48 ±2.02, p=0.03). No differences were found between saline and castile soap (44.86 ±4.28, p=0.91) or the surfactant containing solution (51.86 ±4.37, p=0.811) for oil-based paint injuries.

DISCUSSION: Using a standardized cadaveric model, we determined the optimal irrigant for latex and oil-based paint removal from the human hand as measured by digital image pixel mean intensity. For irrigation of either paint type, saline, which is the current standard of care, was found to be inferior to other solutions. Saline lacks molecules that can bond with paint and wash them away. Latex paint is water based and requires an irrigant that can break the water's surface tension. Solutions with surfactants break hydrogen bonds between water molecules, allowing for latex paint to be scrubbed away, as demonstrated in our study by the improved performance measured with castile soap and the surfactant containing irrigant (Biasurge).

For oil-based paint, solvents such as acetone containing paint thinner are caustic to the human body and can only be used for external removal. As such, this type of solvent is not approved for surgical use. However, molecules present in paint thinner, such as acetone, contain carbonyl groups which break down the oil in the paint, allowing for removal. We found that the ethanol and acetate solution (Bactisure), which is currently approved for use in total joint arthroplasty, was significantly better than saline, castile soap, or Biasurge in the removal of oil-based paint from the injected specimens.

SIGNIFICANCE: Our study found significant differences between four different approved hospital-grade irrigants that can be potentially used in the surgical treatment of latex and oil-based high pressure paint injection injuries to the hand. Additionally, this study proposes the novel idea of using irrigation fluids normally reserved for total joint operations in hand surgery cases. Based on the findings of this experiment, we recommend new standards of care in surgical irrigation fluid choice for both latex and oil-based paint injuries, replacing saline with other currently available irrigation fluids.

IMAGES:

Figure 1. Camera and UV light mount (left), scrubbing apparatus (right)

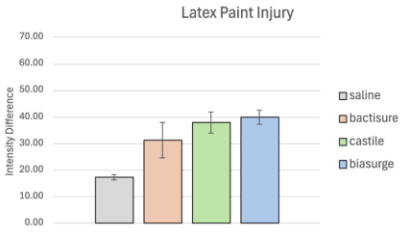

Figure 2. Latex paint results

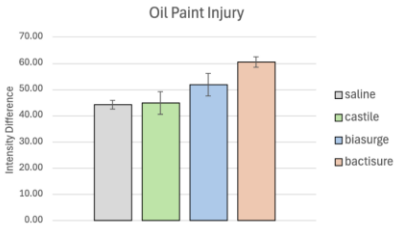

Figure 3. Oil paint results