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Prevention and awareness of pool suction-drain injuries in children: two case reports

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Abstract

Although rare, pool suction-drain injuries may result in potentially fatal consequences: risk of drowning due to hair or extremities entrapment, bowel evisceration, hypovolemic shock, and death. We present two case reports: the first patient was entrapped by a suction grate (placed at the bottom of a water park pool), resulting in an extensive circular lesion on his back; the second child was evaluated for foot entrapment by suction. Both patients were discharged after observation with a good prognosis and without complications. Accidents associated with suction systems are little known, for this reason it is important to emphasize primary prevention. While awaiting new technological tools, public awareness and careful supervision are fundamental. European standards and pool circulation systems must be respected, particularly the use of anti-vortex covers, automatic power cut-offs for filtration systems, dual-drain systems, poolside panic buttons, and supervision of swimmers.

Key words: suction injuries, children's safety, entrapment prevention, case report.

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Introduction

Suction-drain injuries in swimming pools are uncommon and occur when a swimmer, often a child, becomes trapped by suction forces produced by the passage of water through the underwater drainage at the bottom of the pool. They often present a significant risk of fatal consequences, especially in children under eight years of age, who are the most frequently involved.¹

Starting from 1980, approximately 200 cases of entrapments were described, including fifty deaths. Suction injuries can be produced by different mechanisms. The most common is hair entrapment, due to the flow of water dragging hair into the drain. Suction injuries involving the chest, abdomen or limbs are usually the consequence of the absence of grates covering the suction outlets.

Limb entrapment, in particular, can cause compartment syndrome. Sometimes children may remain trapped even after the pool vacuum has been turned off.²

Many cases in worldwide literature describe of intestinal loop evisceration with different degrees of severity: from rectal prolapse to complete evisceration, caused by perineal and anal entrapment.³⁻⁷ The actual incidence of evisceration is unknown, partly because mild cases often go unreported.⁸ In particular, sitting on uncovered pool drains can cause rectal prolapse with sigmoid laceration and subsequent evisceration of the small intestine. This is a well-known pattern of injury, with 11 cases reported in the literature up to the review published in 2010. Of these cases one resulted in rectal prolapse, two cases were rectal/recto-sigmoid

perforation, without small intestine involvement. The other seven cases resulted in evisceration of the small bowel, with varying degrees of damage. The primary mechanism of pool drain suction injuries involves a powerful vortex produced by an exposed drain that creates a circumferential seal, with the anus as its center, making it difficult to escape, even for an able-bodied adult, resulting in rectal prolapse or in a full-thickness rectal tear. Through this tear, negative pressure is transferred to abdominal cavity, resulting in potentially avulsion of the small intestine from the mesentery and subsequent evisceration by rectal laceration. Prognosis is directly related to the amount of small bowel remaining after injury.⁹ For example, patients with 45cm or less of small bowel become dependent on total parenteral nutrition, because at least 25 cm of small bowel is required to maintain circulation, which is essential for liver health. Indeed, the loss of entero-hepatic circulation, together with other associated factors, can rapidly lead to intestinal failure and liver disease.⁷

The final mechanism of pool suction-drain injury is death by drowning, caused by the child being entrapped at the bottom of the pool.¹⁰ In 2019 over 230,000 people worldwide died from drowning and statistics of World Health Organization have documented that the drowning mortality rate is higher among children under 5 years of age (regardless of their gender), while among children under 15 years of age, drowning is the second-leading cause of unintentional death.¹¹

Furthermore, another fatal consequence of pool suction-drain injuries includes hypovolemic shock resulting from the rapid

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redistribution of interstitial fluid and blood.¹² Often these types of accidents are not recognized either by healthcare professionals or pool safety managers.¹³ Awareness is, instead, the first step toward prevention, especially in locations with a high rate of tourism.

In this regard, we present two mild cases reported at our center within a short period, with the aim of raising pediatricians' awareness of this type of trauma, which can often conceal pitfalls.

Case Report

The first patient, a 13-year-old boy, came to our attention because, after a dive, he was entrapped by a suction grate at the bottom of a water park swimming pool. Fortunately, he was able to get out before drowning, reporting only mild pain at the injury site. Upon admission, victim's vital signs were normal, and the physical examination revealed an imprint injury on his back, caused by the suction grate (it was a skin lesion measuring nearly 40 cm at its greatest diameter, extending from the inter-scapular region to the lumbar area, Figure 1). Upon discharge he was followed by his pediatrician and achieved complete remission after six days of topical therapy.

The second child was a 6-year-old boy that was admitted for foot entrapment due to suction (involving the distal third of the left foot, including the forefoot), while bathing in a swimming pool under maternal supervision (Figure 2), through the uncovered opening of a pool drainage system. In this case no fractures or vascular lesions occurred either. He had neither compartment syndrome nor further clinical signs. As a tourist from another European country, he was contacted for telephone follow up after his departure. He reported significant improvement after five days of therapy.

Discussion

Accidents related to suction systems are not commonly known by healthcare providers, parents and professionals who work in public swimming pools, which is why it is important to emphasize primary prevention.¹⁴

Public awareness and careful supervision are important, but pool circulation systems must be considered first. Pool main drains are necessary to maintain water quality by promoting constant circulation, and water filtration systems are primary components of swimming pools. Generally, the drain outlet is closed by a cover. However, if, for any reason, this cover is removed and a child sits on or is sucked into an unprotected drain, a seal is produced that allows the pump to create a vacuum.

The result may be the production of high pressures and varying degrees of damage.⁸ For this reason public and private pools should be equipped by anti-vortex drain covers, which should be checked frequently and replaced if damaged.¹⁵ New drain covers, with improved safety features, have been developed, but there is still a risk of accident, because these devices could break or be dislodged. Vacuum release safety systems have been designed to shut off the pump when they detect a disproportionate vacuum level, but this expensive technology does not automatically guarantee protection from all entrapment cases.

Anti-vortex covers have been developed to reduce the risk of aspiration by preventing injury from direct suction, but hair or fingers can still become trapped. Furthermore, covers are safe only if properly secured and not removed. Indeed, recent computational fluid dynamics studies document that vacuum inlets and skimmers

provide sufficient circulation even without the use of a drain. Actually, a growing literature suggests that vacuum drains are not essential for pool cleaning, and that more efficient and safer alternatives exist, as recommended by European^{16,17} and American government laws and regulations.^{18,19} For example, a possible remedy could be to add an automatic cut-off switch, so that the filter cannot operate if the cover is off, or to install an override system that shut off the filter if the inlet is blocked, limiting the negative pressure peak that can be generated.⁵ Furthermore, to minimize suction power, pool owners must comply with safety rules regulating their facilities. Specifically, the European standards UNI EN 13451-3¹⁶ and UNI EN 16713-2¹⁷ require obstruction tests (when-ever a risk assessment deems appropriate), hair entrapment tests, and tests to verify the suction flow at the grate, to calculate its resistance to release if a body manages to obstruct it.¹

Additionally, pool staff must know how to shut off the power and have the essential access to do so. If supervisory personnel are unavailable, panic buttons and cut-off switches must be accessible



Figure 1. Imprinted lesion by the suction grate on the back of a victim of suction injury.



Figure 2. Entrapment by foot and forefoot suction.

poolside. A study conducted by Davison *et al.* in 2003 proposed several relevant and up-to-date measures for preventing suction injuries: raising awareness of swimming pool hazards among the public and travel companies, providing safety information to be integrated into general advice booklets given to those planning holidays, and ensuring safety measures and regular pool inspections. Particularly essential are the use of anti-vortex covers that are difficult to remove, a filtration system with a simple and accessible power switch, poolside panic buttons, poolside attendants and swimmer supervision. Finally, it would be important to use dual drain systems in new pools (reducing suction force).⁸

Conclusions

Although there are several potential means to prevent accidents, the frequency of suction injuries is believed to be increasing, likely due to inadequate pool safety and the growing use of holiday pools in resorts, where staff are often insufficient or poorly trained.²⁰ Parents should be careful when travelling, especially where pool legislation is lacking or not applied, or where travel times to medical care can be long or language barriers make communication difficult.³ While waiting for technology to develop new systems to guarantee the safety of swimmers (including solutions based on artificial intelligence or the internet), new prevention strategies and widespread public awareness remain the only effective means to reduce the severity and frequency of pool suction-drain injuries.¹¹

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