Vacuum-assisted wound closure following urine-induced skin and thigh muscle necrosis in a cat

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Summary
Vacuum-assisted closure (VAC) is a relatively new technique for wound management in dogs and cats. It was successfully used in this cat to treat severe urine-induced skin and thigh muscle necrosis, resulting from a traumatic urethral rupture. No complications were encountered with application of the VAC technique and production of a healthy granulation bed, suitable for wound reconstruction, was achieved after only five days of VAC treatment. The marked wound contraction (40.3%) obtained after eight days of treatment, was sufficient to allow closure of the defect using a simple, rotational subdermal plexus flap. This was a safe, effective and efficient treatment for a challenging wound in a difficult anatomical location.

Introduction
Vacuum-assisted closure (VAC) of wounds was first described by Fleischmann et al in 1993 for the management of open fractures in people (1). It has since evolved in human medicine to be used in the treatment of a wide variety of acute, chronic and infected wounds (2–4); however, this technique has only recently been introduced into veterinary medicine (5, 6).

Principally, this technique involves the application to a wound, of controlled sub-atmospheric pressure (continuous or intermittent), via an open-pore foam dressing (pore size 400–600mm), which has been shown to accelerate debridement and to improve healing (2, 3, 7). The mechanisms by which healing occurs include early resolution of infection (2, 7), stimulation of cell proliferation and angiogenesis within the wound (2, 7, 8) and increased wound contraction (7). Control of infection occurs due to the active removal of exudate and interstitial fluid from the wound, which reduces local oedema and bacterial numbers (2, 7). In addition, control of infection is due to an increase in blood supply to the wound, which improves local tissue defences (7–9). Accelerated production of granulation tissue is thought to occur due to mechanical deformation of cells within the wound, which stimulates protein and matrix synthesis as well as angiogenesis (7, 8, 10). Increased wound contraction occurs due to a more rapid production of granulation tissue within the wound, and due to the direct mechanical centripetal forces exerted by the negative pressure on the tissue edges (7).

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The use of VAC has been described in fifteen dogs for the treatment of traumatic, distal extremity shearing injuries (5) and in a cat for treatment of a traumatic dorsal wound (6). To the authors’ knowledge, this is the first report of the use of VAC in managing urine-induced skin and muscle necrosis, and only the second report of the use of this technique in cats.

Case history
An 18-month-old, female neutered Siamese cat was referred to our clinic at the University of Bristol for surgical treatment of a urethral rupture, sustained in a road traffic accident one week earlier. Urine leaking from this injury had resulted in extensive tissue necrosis on the proximal lateral aspect of the left pelvic limb. A cystostomy tube had been placed five days earlier to try to provide urinary diversion, but urine had continued to leak into the pelvic limb since this surgery. In addition, the cat had sustained a comminuted, mid-diaphyseal right femoral fracture, which had been repaired by the referring veterinary surgeon using an intramedullary pin and a type 1a, four-pin external skeletal fixator.

On presentation, the cat was quiet, but alert, and weighed 3.4kg. No cardiovascular or respiratory abnormalities were identified. Examination of the pelvic limbs revealed moderate soft tissue swelling and bruising in both limbs. There were no obvious problems with the external skeletal fixator on the right pelvic limb, but an extensive necrotic wound was observed on the left pelvic limb. This wound extended proximally from the cranial ilium to the tail base along the dorsal midline, and distally to the level of the stifle joint cranially, and to the mid crus caudally. The cat was ambulatory, but displayed bilateral lameness and weakness of the pelvic limbs.

Blood samples obtained for haematology and biochemistry revealed a mild anaemia (haematocrit 20.7%, range 25–45%), band neutrophilia with toxic change (total neutro-
phil count 13.21 x 10^9/l, range 2.4–12.5 x 10^9/l; band neutrophils 3.26 x 10^9/l, range 0–0.3 x 10^9/l), hypokalaemia (2.9 mmol/l, range 3.7–5.8 mmol/l) and hyperglycaemia (12.6 mmol/l, range 3.9–8.3 mmol/l). Intravenous fluids supplemented with potassium were administered and analgesia was provided using buprenorphine\textsuperscript{a} 0.02 mg/kg IV. Lateral and ventrodorsal pelvic radiographs identified the comminuted right femoral fracture repair, but no other orthopaedic injuries. A positive-contrast retrograde vagino-urethrogram revealed an avulsion injury of the vagina and distal urethra, with marked contrast leakage into the surrounding tissues (Fig. 1).

The severity of the lower genitourinary tract injuries rendered surgical repair of the urethra impossible and a prepubic urethrostomy was performed as a salvage technique. The necrotic wound on the left pelvic limb was debrided (Fig. 2), samples were obtained for tissue culture and a tie-over wet-to-dry dressing was applied. This dressing was changed daily under general anaesthesia for five days. As the tissue culture revealed a mixed growth of aerobes sensitive to a range of antibiotics\textsuperscript{c} seven day course of oral potentiated amoxycillin\textsuperscript{b} was administered. The cat was urinating well, without any straining, through the new urethral stoma within 24 hours of surgery and was continent.

Re-assessment of the left pelvic limb wound five days after admission revealed only a small (11.6%) reduction in wound surface area (Fig. 3). Minimal granulation tissue had developed and the tissue edges were under-run circumferentially, resulting in large pockets of dead space, particularly in the caudal aspect of the wound (Fig. 4).

Following limited progress with tissue healing at this stage, VAC therapy was applied for eight days, with the aims of accelerating healing, closing dead space and inducing sufficient wound contraction to allow secondary wound closure. On each occasion, under aseptic conditions and general anaesthesia, open pore foam\textsuperscript{c} (pore size 400–600 mm) was contoured to the shape of the wound, but was cut approximately 1 cm smaller circumferentially to encourage wound contraction. Adhesive hydrogel strips\textsuperscript{d} were applied around the wound edges and after positioning of the foam within the wound, adhesive drapes\textsuperscript{e} were applied to cover the entire area, carefully avoiding the anus, vulva and new urethrostomy site. A hole was cut in the plastic drape and a suction pad\textsuperscript{f} was applied and connected to the VAC unit\textsuperscript{g} (Fig. 5). The cat was re-

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\textsuperscript{a} Vetricin, Alstoe Animal Health, UK
\textsuperscript{b} Synulox, Pfizer, UK
\textsuperscript{c} VAC Granufom, KCI medical, UK
\textsuperscript{d} VAC gel, KCI medical, UK
\textsuperscript{e} VAC drape, KCI medical, UK
\textsuperscript{f} T.R.A.C. pad, KCI medical, UK
\textsuperscript{g} VAC Freedom, KCI medical, UK
covered from anaesthesia and a suction pressure of –125 mm Hg was applied continuously to the wound. The technology in this system (Therapeutic Regulated Accurate Care) ensured that this vacuum was maintained throughout the period of treatment. Tolerance of the apparatus was good, with the cat demonstrating normal movement around the cage and use of the litter tray to urinate and defecate. In addition, the cat’s mobility did not disrupt the suction of the machine or the dressings. An Elizabethan collar was maintained at all times to prevent direct patient interference. The VAC dressing was changed twice; first at 48 hours after application and then a further 72 hours thereafter.

Wound granulation was sufficient to enable reconstructive surgery after only five days of VAC therapy; however, treatment was continued for a further three days to increase wound contraction, thus reducing the wound size and the difficulty of secondary closure. Eight days following initiation of VAC therapy, blood samples were obtained for repeat haematology and biochemistry and revealed only a mild hypoalbuminaemia (21.7 g/l, range 24–35 g/l). A total of 400 mls of exudate had been retrieved from the wound during the eight day treatment period, and a 40.3% reduction in wound surface area had been achieved (Fig. 3). The VAC apparatus was removed (Fig. 6) and the surrounding skin was clipped and prepared for aseptic surgery. Extension of the dorsal edge of the wound by a cranially directed incision created a rotational flap, which was used to cover almost all of the wound area. The superficial iliac vessels were identified and preserved to improve blood supply to the skin flap. Vertical mattress sutures were placed at the caudal limit of the skin flap and simple interrupted sutures were used to oppose the skin edges circumferentially (Fig. 7). A deficit, measuring approximately 2 cm x 3 cm remained on the caudo-lateral thigh, but this resolved rapidly by second intention healing. Two weeks postoperatively, the skin sutures were removed and wound healing was complete 28 days after admission.

Four months later, telephone contact was made with the referring veterinarian, who reported that there were not any wound problems. The cat was still urinating well through the prepubic urethrostomy, but there had been minor problems with urine scalding which was treated using a topical cream.

**Discussion**

Urethral rupture, which is an uncommon injury in cats, occurs predominantly secondary to urethral catheterisation (iatrogenic) or ve-

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Fig. 3  Graph demonstrating the reduction in surface area of the wound during treatment. The wound surface area was calculated from digital photographs using planimetry software. The dorso-plantar dimension of the tarsus at the level of the medial malleolus was used as a reference scale. Arrow denotes start of vacuum-assisted closure.

Fig. 4  Day 5: Wound after five days of wet to dry dressings

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\[^3\] Fuciderm gel, Leo Animal Health, UK

\[^i\] Universal Desktop Ruler, AVPSof.com

Vacuum-assisted closure was applied to the wound with the aims of resolving infection, completing wound debridement, reducing the time needed to produce a healthy granulation bed, and increasing wound contraction (2). Using this technique, a healthy granulation bed suitable for wound reconstruction was achieved in only five days, which we suggest was faster than the predicted response using conventional dressings (15, 17). Unfortunately no control was available to prove this unequivocally; however, in an experimental study in cats, the median time to coverage of the bottom of a 2 x 2cm wound bed with granulation tissue was 18 days (17), which is substantially longer than that seen in this case. The response seen is also in agreement with results obtained in an experimental study in pigs and in a prospective trial in human beings, comparing saline moistened gauze swab dressings with VAC therapy (7, 4). In pigs, investigators demonstrated a 63.3% increase in the rate of granulation tissue production with VAC therapy compared to the saline gauze treatment (p<0.01) (7). In human beings, VAC therapy has been demonstrated to produce superior wound healing in chronic wounds, with the most significant difference relating to reduction in wound depth, which was 66% for VAC treated wounds, compared with only 20% for gauze dressings (p<0.00001) (4). In the previous report of treatment of a dorsal skin wound in a cat, the authors’ commented that healthy granulation tissue was produced in only 48 hours, and a faster reduction in wound size was achieved than that which occurred during a subsequent three week period of using conventional dressings (6). These comments continue to support our findings.

In this cat, VAC therapy was continued for an additional three days beyond production of a suitable granulation bed to achieve further wound contraction, which in turn reduced the difficulty of wound reconstruction. Increased wound contraction was achieved in this case by cutting the foam 1cm smaller than the circumference of the wound in order to increase the centripetal forces applied to the skin edges, thus resulting in skin stretching.

In similar cases without the femoral fracture or urinary tract complications, more traditional methods of wound reconstruction may have been used, such as axial pattern...
or transposition flaps. In this particular cat however, use of the caudal superficial epigastric flap was avoided to reduce potential complications with the prepubic urethrostomy site, such as urethral kinking. The proximity of the wound to the tail base and perineum, prevented the use of caudal skin; the fracture of the right pelvic limb, repaired with an external fixator, prevented rotation of skin over the midline into the defect. Only the skin cranial to the defect was readily available for wound reconstruction, and once the size of the wound had significantly reduced, a simple rotational subdermal plexus flap was used to achieve secondary closure, which healed uneventfully.

Although this appeared to be a difficult location in which to apply this type of dressing, very few problems were encountered. Commercial adhesive strips designed for use in people were used to secure the dressing, and these adhered very effectively to cat skin. The adhesive drapes could be moulded as necessary around the perineum and medial aspect of the thigh to secure the foam and to ensure that appropriate suction could be maintained. Occasional small leaks were audible, but the commercial VAC unit was able to make adjustments and maintain −125mmHg of pressure with these minor disruptions.

No major complications were encountered using this technique in this cat. The only minor complication was ingrowth of granulation tissue into the foam, which occurred when it was left in position for periods of 72 hours. This problem was overcome by soaking the foam in saline before removal to prevent damaging the tissue, and it could have been prevented by using foam with a smaller pore size and increased density, which reduces ingrowth of granulation tissue (18).

Although the cost of applying VAC is greater per day than that of using conventional dressings, the reduced hospitalisation and number of dressing changes required results in an overall cost, which is similar, if not less than traditional open wound management (3, 19). The reduction in number of dressing changes is also advantageous for the patient, enabling improved nutrition, with reduced days of forced starvation for sedation or anaesthesia, and reduced stress and risks associated with each dressing change.

In conclusion, vacuum-assisted wound closure can be successfully used to treat acute, urine-induced, necrosis injuries in cats in areas that are difficult to dress by conventional means.

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References