Treatment of recalcitrant seroma with a novel hybrid tube-drain system: Review of the postoperative seroma management and case reports

Key words:

- *Negative pressure wound therapy*
- *Seroma*
- *Surgical wound*
- *Vacuum assisted closure*

Current literature presents four techniques of management of seroma — open NPWT, bedside aspiration and/or drain insertion, surgical capsulectomy and chemical sclerotherapy. We present two cases of access related seromas: one, a case of recalcitrant seroma post-autologous arteriovenous dialysis access creation, and another patient who developed a perigraft seroma adjacent to the venous anastomosis. The existing techniques were either trailed with poor effect or deemed unsuitable. Both seromas were eventually treated using a modified closed incisional negative pressure therapy (ciNPT) system to prevent secondary infection (SSI), drain the seroma and allow skin union. Here we describe this modified technique.

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Negative wound pressure therapy (NPWT) has been approved for open wound closure by secondary intention, in the US since 1995. In recent years, variants of NPWT have been devised to treat both open wounds and closed incisions (closed incisional negative pressure therapy, ciNPT). Of note, ciNPT has been shown to reduce risks of wound infection, dehiscence and seroma formation across diverse surgical wounds in different parts of the body (Hyldig et al., 2016; Shiroky et al, 2020). Postoperative seromas most commonly occur after axillary surgery (van Bastelaar et al, 2018), surgery to the groins (vascular bypass surgery, lymph node dissections and surgery in previously operated groins) (Contreras and Jakub, 2020) and inguinal hernia mesh repairs (Dauria et al, 2006; Li et al, 2019. They can cause discomfort and pain and carry the risk of secondary infection. Complete resolution after conventional therapy often requires weeks to months. Emerging technologies tend to focus on facilitating bedside drainage, for example Seroma-Set (Innoventa Medica) or making sustained closed percutaneous drainage more patient-friendly, such as SOMAVAC 100 (Somavac medical).

The literature currently describes four techniques of management of seroma — open NPWT, bedside aspiration and/or percutaneous drain insertion, surgical capsulectomy or chemical sclerotherapy. To date, there have been no reports of ciNPT systems used to treat seromas as they are designed for application onto closed incisions, and studies relating ciNPT to seromas have only examined rates of seroma formation.

Here we present an unusual case of a symptomatic postoperative seroma complicating a newly-created brachiocephalic arteriovenous fistula, which compromised flow-rate and threatened its maturation. The patient was eventually treated with a modified Prevena (3M) system, resulting in rapid resolution of the seroma and union of the incision line. Complete resolution was achieved within 10 days of applying the modified system. There were no complications at two months and the fistula was cannulated successfully. Another patient who developed an axillary perigraft seroma adjacent to the venous anastomosis discharging through a sinus on the previous suture line was treated with in an identical fashion and resolved within 7 days of initiation of therapy.

Overview of literature

Seroma formation is an uncommon but potentially serious complication of haemodialysis access creation. If undetected or left untreated, it can lead to infection and

stenosis of a fistula, and consequently to failure of maturation or even thrombosis. The incidence of seroma formation post haemodialysis access creation is about 0 to 6% (Dauria et al, 2006; Demiral, 2017), but appears to be more common when prosthetic grafts are used (Oliver et al, 2001). Treatment for seromas range from conservative management with extrinsic compression or closed aspiration to open drainage with surgical excision of the seroma pseudocapsule (Dauria et al, 2006).

A systematic search was performed on PubMed using the following terms: "seroma", "drainage", "therapy", "dressing". There were 351 search results, with the majority of articles focusing on primary prevention of seroma, which we excluded. The remainder described seroma treatment techniques which conformed to the earlier-mentioned methods but with varying methodologies and equipment. Among the more contemporary articles, we found the following noteworthy for being particularly well described.

Wigbers et al (2021) laid open seromas using a 2 to 3 cm incision and packed the wound cavity using a sterile glove "flap", upon which they laid 2 layers of absorbent dressing to soak up secretions. This supposedly allowed the wound cavity to remain sterile while enabling the patient to change the outer-most pad whenever it became soaked, which they described as "daily as needed". The inner layers had to be changed approximately twice a week. Marangi et al (2020) performed laying open and capsulectomy of chronic seromas, followed by NPWT for about 3 weeks, followed by either primary wound closure with closed suction drain or healing by secondary intention. Similarly, Adedigba et al (2021) described resolution of a perigraft seroma only after surgical resection of pseudocapsule. Temiz et al (2015) described a bedside procedure for inserting a percutaneous drain using a suprapubic urinary catherization set, largely similar to a conventional drain, as did Becker and Klimczak (2016) who used a commercially produced SeromaCath for post-breast-implant seromas. Bissaco et al (2017) described capsulectomy and replacement of prosthetic extra-anatomical vascular bypass grafts with grafts of different materials after failed percutaneous or surgical drainage of periprosthetic seromas. Ali-Khan et al (2009) described erythromycin injection into the seroma cavity for post breast and inguinal operations to good effect, as did Berkoff et al (2013) who injected fibrin glue into post-arthroscopic knee-seromas. The above findings have been summarised into ***Table 1***.

Case 1

A 76-year-old Chinese gentleman with a medical history of diabetes mellitus (DM), treated by subcutaneous insulin, hypertension, hyperlipidaemia and end stage renal failure secondary to diabetic nephropathy, for which he was dialysing via a temporary haemodialysis catheter. Significantly, he also had two previous surgeries for recurrent right thigh pT2 Merkel cell

Table 1. Current literature on management of postoperative seroma

Authors, country (year)	Type of article	Site of wound, open or closed	Operation	Treatment	Average time to wound recovery and seroma resolution
Wigbers et al Germany (2021)	Case report	Inguinal, open	Inguinal crossectomy	2–3 cm laying open, sterile glove "flap" packing, conventional sterile compress, followed by a replaceable overflow absorbent pad. Primary closure later date?	2 weeks
Marangi et al Italy (2020)	Case series	Various body parts, open	Morel-Lavallée lesions, post abdominoplasty or lymphadenectomy	Open capsulectomy followed by NPWT for an average of 3 weeks, followed by primary wound closure with closed suction drain placement	2 months
Temiz et al Turkey (2015)	Case report	Various body parts, closed	Flap operations	Bedside drain insertion using suprapubic urinary catherisation set	Not mentioned
Bissaco et al Italy (2017)	Case series	Axillo-femoral or femoro-femoral bypass grafts	Extra-anatomic bypass	Percutaneous or surgical drainage (4/5 failed), followed by complete replacement of graft	Post-procedure resolution with nil to mild recurrence of seroma within 12 months
Ali-khan et al United Kingdom (2009)	Case series	Breast and inguinal	Breast reconstruction, inguinal lymphadenectomy	Erythromycin injection into seroma cavity through existing drain after failure of closed drainage	Nil recurrence within 1–2 weeks of injection. Some skin irritation / inflammation resolving spontaneously

carcinoma, both were complicated by prolonged postoperative seromas treated with open NPWT.

He underwent an uneventful left arm brachio-cephalic (BC) AVF creation under local anaesthesia (LA). Preoperative on-table ultrasound scan failed to identify the upper arm cephalic vein as it was extremely contracted, but a prior formal venous duplex had sized it at around 2 to 2.4mm. The median cubital vein was identified intraoperatively and anastomosed to the brachial artery in an end-to-side fashion. While it was initially small and contracted at 1mm, water-dilation with heparinised saline flushing brought it up to 2.5mm. A good thrill was palpated postoperatively at the elbow and upper arm.

On postoperative day (POD) 1, the thrill from the fistula and left radial pulse were well felt. However, there was a 2cm subcutaneous lump in the region of the anastomosis with no active bleeding from the suture line. A duplex ultrasound scan of the fistula was negative for pseudoaneurysm and the patient was discharged with an early follow-up appointment and prophylactic oral antibiotics.

When reviewed in the clinic two weeks later, the patient complained of discomfort and mild tenderness with progressive swelling of the forearm. There was mild erythema and diffuse swelling tracking down the forearm and a more focal swelling in the region of the now healed elbow wound. Very slight tracking ecchymosis was noted from the medial end of the wound, but the elbow wound was non-tender. The upper arm thrill was preserved but diminished. The decision was made to admit the patient for re-assessment to exclude pseudoaneurysm or a possible abscess. Repeat duplex ultrasound of the fistula did not demonstrate a pseudoaneurysm, but there was a severe (>75%) stenosis of the vein in the juxta-anastomotic segment down to 1.2mm, with resultant poor flow rate of 272 ml/min.

The patient was counselled for wound exploration with potential drainage of haematoma or abscess and possible on-table fistuloplasty and was agreeable for surgery.

Intra-operatively no abscess or haematoma was found, but the wound had a large amount of accumulated haemoserous fluid which was drained. The anastomosis was intact with no bleeding from the suture line. As per the duplex ultrasound study, the juxta-anastomotic venous outflow was small at around 1.5mm, presumably from pressure effect, but the rest of the AVF was a good size 4mm. The thrill in the cephalic vein towards the shoulder was poor. A couple of branches decompressing towards the forearm were dissected in the lateral wound and ligated and the wound was washed copiously before closure with Prolene 3/0. We decided not to perform concurrent fistuloplasty as the narrowed segment was already larger at the end of the surgery at around 2.5mm with improvement in thrill of the superior decompressing cephalic vein, and we felt that the underlying problem was probably a combination of compression from the seroma and proximal decompression of the vein from the two now-ligated decompressing veins. There was also concern that balloon dilatation of the dissected segment might result in troublesome bleeding.

Over the next few days there was severe re-accumulation of serous fluid with seepage

Table 2. Summary of events and drain output

POD	**3**	**4**	**5**	**6**	**7**	**8**
Event	Nelaton tube overlying gauze on wound surface	Minivac tube through sutures connected to wall suction	Tube dislodged	Tube replaced	Prevena applied 125mmHg suction, intermittent	Modified Prevena applied, 75mmHg suction, continuous
Daily Drainage /(ml)	15 (large amount of fluid reaccumulated in wound)	200 (less fluid reaccumulating but still seeping, suction seal lost after 18 hours)	0 (large amount of fluid reaccumulated in wound)	100 (suction seal lost for unknown duration, reaccumulating of fluid in wound)	Minimal (large reaccumulating of fluid in the wound)	30
POD	**9**	**10**	**11**	**12**	**16**	**18**
Event	Nil, drain system intact	Discharged home	No change	Modified Prevena adjusted to 50mmHg suction, continuous	Modified Prevena adjusted to 25mmHg suction, continuous	Patient self-removed Modified Prevena
Daily Drainage (ml)	300	300	300	150	100	0

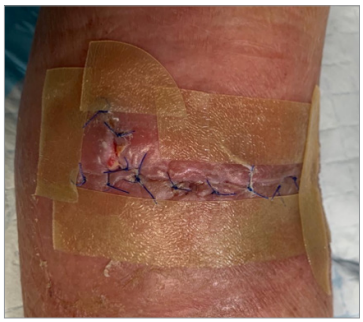

Figure 1. Application of hydrocolloid dressing to wound edges

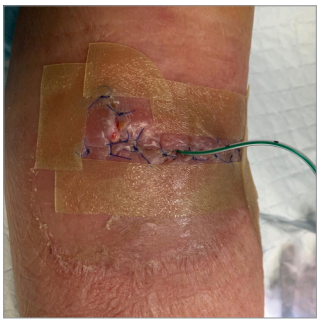

Figure 2. Cannulation of drain via site of non-union in incision through which seroma is seeping through

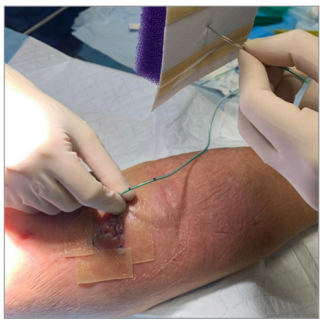

Figure 3. Puncturing the NPWT sponge with drain spear

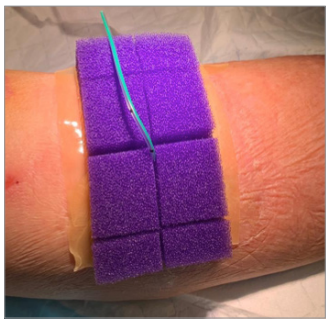

Figure 4. Parachute down of NPWT sponge on to incision

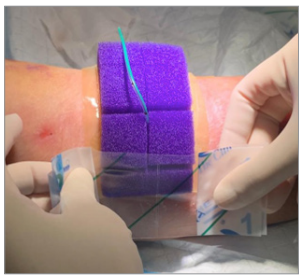

Figure 5. Anchoring the sponge with accompanying sticky drapes

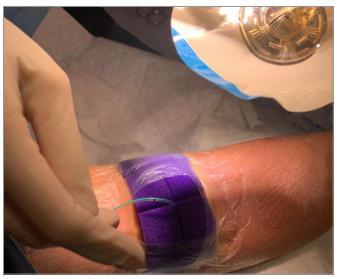

Figure 6. Application of SENSATRAC pad

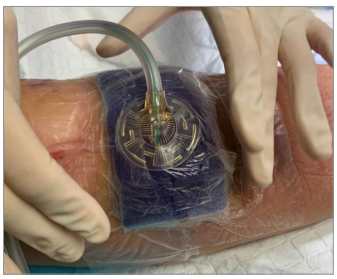

Figure 7. Final construct with drain visible within SENSATRAC lumen

through the suture line and marked recurrence of the elbow swelling despite daily manual expression of the fluid, which expressed large quantities under pressure from a single point between 2 of the sutures. Several attempts were made to reduce the seepage including application of a homemade suction dressing made using:

1. A Nelaton catheter placed over the wound edge (with a piece of gauze as buffer) and sealed with Tegaderm, connected to wall-suction at 125mm Hg, and
2. Placement of a 5F (MiniVac, Unomedical Singapore Limited) drain tubing directly through the decompressing point between the sutures connected to wall suction and sealed with Tegaderm.

These methods were unsatisfactory with either ineffective fluid drainage for the former, which just resulted in transient sealing of the expression site and consequent re accumulation of seroma (which decompressed explosively through the sealed drainage point when manual pressure was applied) or temporarily effective drainage until the seal was inevitably lost hours later for the latter. Cultures sent intra-operatively returned negative. Union between the other sutures was also slow with slow seepage of fluid between them. The forearm swelling improved with crepe compression dressings and arm stockings, but returned slightly when the crepe was removed.

After about a week we decided to try using a Prevena dressing over the wound for fluid management, however this disappointingly resulted in tamponade and sealing of the decompressing point and minimal drainage over 24 hours with severe reaccumulation of the fluid with a large visible lump. We then modified the dressing to drain the seroma, described pictorially in *Figures 1–7* and events summarised in *Table 2*. The margins of the suture line were lined with hydrocolloid dressing (DuoDERM Extra Thin, Convatec Group PLC) and a 5F drain tubing (Minivac) was inserted about 5mm deep through the decompressing point in the suture line into the wound. The other end of the tubing was tunnelled through the Prevena dressing material (Kinetic Concepts, Inc) and foam using the included spear and tucked into the central lumen of the SENSAT.R.A.C. Pad (Kinetic Concepts, Inc) as it was placed down onto the closed wound.

On review over the next 2 days, the system provided consistent and durable drainage with 300ml drained per day, and his forearm swelling resolved. The patient was discharged with advice to chart the drainage daily and followed-up closely in clinic. The drainage was observed to reduce well with reducing need for canister changes, and by day 9 post-discharge

the patient removed the system by himself after noting that the fluid drainage had stopped for a day (ten days after first application of the modified system).

He was reviewed in clinic the next day, and bedside ultrasound showed no visible collection with a good sized AVF of 5mm with good flow. There was complete skin union and the sutures were removed. A repeat duplex ultrasound scan of the AVF a week later showed doubling of the flow rate and improvement of the juxta-anastomotic vein diameter to 3mm — previously compromised by mass effect of the seroma. There was no collection seen.

Case 2

An 80-year-old Chinese lady with a history of hypertension, hyperlipidaemia, DM, peripheral arterial disease with bilateral forefoot amputation, ischaemic heart disease with previous percutaneous coronary intervention, and end stage renal failure on haemodialysis underwent surgery for creation of a left brachial-axillary arteriovenous graft (AVG). Upon review in clinic three weeks later all the wounds appeared well-healed and the sutures were removed and cannulation of the graft initiated. However she returned a week later complaining of fluid draining from her axilla requiring frequent dressing changes. Upon close inspection a small 1mm sinus was found at the most posterior aspect of the healed axillary suture line discharging serous fluid. Bedside ultrasound demonstrated a 2x2x6cm seroma adjacent to the venous limb of the graft at its anastomosis with the axillary vein. There was no pain, tenderness or cellulitis. An ultrasound guided aspiration was performed at the bedside and the fluid was sent for culture. The wound was dressed with daily povidone gauze. She was reviewed a week later in clinic with subjectively reduced but persistent drainage from the sinus, which was visible during wound inspection as a slow leak during manual expression. Bedside ultrasound scan showed that the cavity was now 1x1x3 cm. The cultures showed the presence of *Proteus mirabilis*. She was admitted and commenced on culture-directed antibiotics, and the same modified Prevena dressing was applied in an identical fashion as before, with initial pressure set at 75mmHg, reducing serially over 2 days to 50 then 25mmHg after confirming minimal <5mls drainage into the machine each day. She was discharged on the third day and reviewed a further four days later in clinic. There was no further seroma cavity demonstrable on bedside ultrasound and the VAC dressing and miniVAC tube were removed. The sinus was observed to be dry on manual expression and was sutured closed. The suture was removed a week later with good skin union observed.

Discussion

Prevena is an NPWT intended for closed surgical incisions which has been shown to reduce surgical site incision infections as well as other wound complications. A biomechanical study of how Prevena helps to reduce seroma occurrence suggests that changes in local tissue stresses in the presence of surgical trauma are negated or reduced by the dressing, reducing disturbances to lymphatic flow (Wilkes et al, 2012). As confirmed by isotope tracer study, the negative pressure does not communicate through the skin with the subcutaneous space to directly remove seroma (Kilpadi and Cunningham, 2011).

The challenge in the case of our first patient was due to an already established and recalcitrant seroma collecting in the subcutaneous wound space, which could only be effectively drained by manual expression. This resulted in seepage of fluid through the suture line and surrounding tissue oedema which left the skin macerated and impaired skin union, as well as compromised watertight sealing of the various jury-rigged drainage systems we applied. The superficial nature and relatively small wound cavity also made accidental de cannulation of the drain a major problem. These were well addressed by the Prevena system which is strongly adhesive and intrinsically watertight owing to the hydrocolloid gel linings. The reaccumulating of the seroma despite applying the Prevena (and failure to drain any fluid) in its unmodified form further confirmed that the external negative pressure could not communicate through the decompression point in the suture line with the wound space and was probably buttressing it closed. This was solved by cannulating the wound edge using a MiniVac tubing and passing it directly through the Prevena foam into the suction pad lumen to ensure transmission of the negative pressure through the wound edge into the wound cavity.

Our modified system was easily performed by the bedside, and was the most durable and most effective at draining fluid and preventing re-accumulation amongst the rest of the trialed techniques. It allowed the seroma to drain effectively while also applying ciNPT to the wound edge. Furthermore, the system was portable and provided a durable, sterile water-tight seal, which allowed the patient to

be freely ambulant to the extent that she could be discharged home while awaiting reduction in fluid volume. Additionally, the system maintained the benefits of the original Prevena system in preventing surgical site infection and enhancing healing by primary intention of the surgical wound. Notably, the seroma had completely resolved and full skin union had been achieved within 10 days of application of our modified system.

In comparison, the techniques described above by other authors may not have worked as well or been appropriate in this patient for the following reasons:

- Serial percutaneous aspiration would have been very frequent (probably daily, bearing in mind the high daily output of the seroma compromising the flow and maturation of the AVF by mass effect) and extremely unpleasant for our patient
- Open capsulectomy and application of NPWT (Marangi et al, 2020) would have risked of erosion of the blood vessel by contact with the foam, and potentially have been much slower over 2 months compared with the 10 days we observed. Further operation for primary closure would also have been required
- Conventional ultrasound-guided percutaneous drain insertion would have been challenging due to the relatively small cavity and close proximity to fairly large high-flow blood vessels; placement of a large bore tube (Temiz et al, 2015) would have been impossible
- Replacement of the vein with a prosthetic graft (Bisacco et al, 2017) would have negated the intrinsic benefits of using native vein with respect to long term patency and resistance to periprosthetic infection
- Chemical sclerotherapy (Ali-Khan et al, 2009) would not have addressed the mass effect from fluid compromising fistula flow and may have threatened the viability of the AVF through local inflammatory and fibrotic responses (Sood et al, 2017), which can cause extrinsic scarring and consequently venous stenosis or even occlusion. Injury to the vessel wall must also be avoided as it can result in pseudo aneurysm formation or bleeding
- The "glove in a hole" technique described by Wigbers et al (2021) may have exposed the vein to tracking infection along the glove, or through the 3cm open wound with resultant risk of stenosis or rupture, and frequent soaking of the secondary dressings requiring changing 2 to 3 times a day would have been unpleasant for the patient. The prospect of another operation to close the wound would also have been unappealing.

Similarly, our second patient presented a challenge as the seroma was adjacent to the conduit. In this case the conduit was a prosthetic graft raising the spectre of graft infection, and the seroma was already exposed to the environment via a small sinus. Serial percutaneous drainages over a protracted period would have run the risk of eventual infection of the graft and an expedient solution seemed most desirable. Previously, we would have laid the cavity open and applied a VAC dressing as per Marangi et al (2020), which would have resulted in a larger defect and longer healing duration, however having learnt from the previous case we opted to use our modified ciNPT system with rapid resolution within a week of application.

Conclusion

Review of the literature relating to treatment of postoperative seromas suggests that conventional techniques entail surprisingly long durations and accept a fair amount of patient discomfort (and even pain, in the case of erythromycin instillation). The techniques appear dated, with the most recent advancement being the application of NPWT after open debridement and capsulectomy. Our modified Prevena system appears to have allowed for patient comfort without need for an open wound, and consistent and durable drainage of the seroma collection, and carries the additional benefit of enhanced union of the suture line through ciNPT. The resolution of seroma within 7 to 10 days from application of the system was also remarkable. This technique may also prove useful in the treatment of postoperative seromas associated with bypass grafts or in seromas occurring in other parts of the body e.g. the axilla or groin after breast or general surgery. Application of the technique prophylactically rather than postoperatively in selected high-risk surgeries or patients may also yield interesting results. Further studies should be done to compare the efficacy of our technique against other more established techniques and discern if rapid resolution of seroma is the norm rather than exception. WAS

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