A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods

L Heskin¹, V Cahill², G Filobos³, P Regan⁴, ST O'Sullivan¹, K Bryan²

¹Cork University Hospital, Cork, Ireland

²Cork Institute of Technology, Cork, Ireland

³Frenchay Hospital, Bristol, UK

⁴University College Galway, Ireland

ABSTRACT

INTRODUCTION The importance of postoperative drain fixation cannot be overemphasised. There are numerous described techniques for drain fixation. However, to our knowledge, there is no evidence-based comparison between the various techniques of drain fixation used in postoperative management. We describe a new method and compare its reliability with four other commonly used methods.

MATERIALS AND METHODS Five methods were chosen for testing based on current trends in clinical practice: centurion sandal with plastic locking ties, centurion sandal or lattice method, centurion sandal with half-inch Steristrips®, double and multiple looped methods. We used an Instron 8872® tensiometer to apply a measured force to a secured drain. Each fixation method was tested ten times and all fixation methods were performed by the same experienced surgeon. We measured the average number of cycles before failure, the average displacement of the tube at failure and the time needed to apply each fixation method.

RESULTS The number of cycles completed before failure showed that the centurion sandal method, the centurion sandal with plastic ties and the centurion sandal method with Steristrips had the lowest failure rate. The amount of displacement was the least in the centurion sandal with plastic ties followed by the double-loop method and centurion sandal with Steristrips. There was little difference in the time taken to complete the fixation methods (range 21–33 seconds).

DISCUSSION We recommend the use of the centurion sandal with plastic locking ties, centurion sandal with Steristrips followed by the centurion sandal method alone as fixation techniques that are quick to perform, secure and reliable.

KEYWORDS

Drain, securement – Drain fixation – Surgical drain – Drain reliability – Displacement

Accepted 13 July 2018

CORRESPONDENCE TO

Leonie Heskin, E: Leonieheskin@rcsi.com

Introduction

Postoperative drains are placed much more selectively today. Any drain that is inserted is usually to prevent the accumulation of a haematoma or seroma where this is necessary.¹ The dislodgement of a drain prematurely or the retraction of the drain into the wound can have significant adverse outcomes for the patient.² The factors that influence the security of the drain are the snugness of the wound around the drain, the fixation method used by the surgeon and the external pull on the drain, either from the weight of the collection bag, lack of additional adhesives around the site or indeed levels of patient mobility postoperatively.

The fixation method used depends on the individual surgeon. This study analyses the surgeon's choice, the types of

fixation described in the literature and the evidence documenting the reliability and security of methods commonly used. Although there are many drain fixation methods described in the literature, there are no studies, to our knowledge, that examine qualitatively the security of common fixation methods used to fix postoperative drains and compare them with each other. The authors also describe a new hybrid method for combining two existing described fixation methods, the centurion sandal method and the plastic locking tie method.^{3,4} We hypothesise that this hybrid method will be a solution to the security of fixing both postoperative and chest drains. This study also compares this method with four other drain fixation methods to assess and compare their reliability. Appendix 1 details the different drain fixation methods described in the literature.

Materials and methods

A survey was conducted within Cork University Hospital, the largest university teaching hospital in Ireland. Fifty surgeons from all specialities (consultants and senior registrars) were asked to fill in a survey stating their fixation method of choice when securing postoperative drains and chest drains. There was a 60% response rate ($n = 30$) to the survey. Eighty-five percent of the consultants reported completing specialist training outside of Ireland. The survey found that methods of drain fixation most commonly used demonstrated that 90% of surgeons used the centurion sandal or lattice technique, 6.6% used the double-loop technique and 3.3% used a multiple loop technique.

Based on the results of this survey, three commonly used methods were selected to compare with our proposed hybrid centurion sandal technique with two plastic ties method (Fig 1). Our hypothesis was that the ties would reinforce the centurion sandal method by increasing the securing tension around the lattice suture and also by keeping the lattice in place. For this reason, we included a fifth method where the centurion sandal was secured by Steristrips® as another method to address holding the lattice suture in place (Fig 2).

The five methods chosen for testing were: 1) the centurion sandal or lattice method with an additional two plastic locking ties; 2) the centurion sandal alone; 3) the centurion sandal with half-inch Steristrips; 4) the double-loop method; and 5) the multiple loop method.

The centurion sandal or lattice method has been well described (Fig 3).⁵ The double loop is similar to a clove hitch suture to the base of the drain (Fig 4).⁵ In the multiple looped method, the suture is wrapped around the drain and tied to the other strand with a full reef knot. This process is repeated eight times along the drain (Fig 5). A 1/0 silk suture was used on each occasion for its braided and high knot security features.

We used an Instron 8872® tensiometer to apply a measured force to a secured quarter-inch round PVC drain (BARD®; Fig 6). A custom-made drain guide and clamp were inserted into the tensiometer. We chose to concentrate on the interface between the drain and the fixation method chosen and a metal loop was chosen to simulate human skin. This enabled us to test the behaviour of the drain and the reliability of the fixation method and not the suture-skin junction.

To mimic the real-life stresses to which drains of each fixation methods are subjected, we decided not to apply an

Figure 1 Centurion sandal with two locking plastic ties.

Figure 2 Centurion sandal with Steristrips®.

unnatural continuous force to the drains. To mimic patient movements and intermittent stresses that occur on the ward in the hospital setting, the tension was applied to one end of the drain in a cyclical pulsed loading fashion as opposed to a continuously applied force. Silk sutures have a tensile strength of 10 Newtons (N) and the energy to break point is 33.7 N/mm.⁶ During each cycle, the force was increased gradually to a force of 30 N and repeated until failure. The cyclical force was measured using Blue-hill® software measurements displayed with real-time graphs and numerical values.

Each fixation method was tested ten times, the standard in the current literature, to increase validity of the results, and all fixation methods were performed by the same experienced surgeon.^{7,8} The measurements taken included the average number of cycles before failure. Failure was defined as exposure of the black dot of the drain, which is below the skin surface, or fracture of the suture (Fig 7). We also measured the average displacement of the tube at failure as the distance in millimetres from its initial position. We also recorded whether the drain slipped through the fixation method completely. Analysis of variance was used to investigate evidence of a difference in the average number of cycles completed

before failure and average displacement between the groups. If there was evidence of a statistically significant difference, multiple t-tests using a Bonferroni correction were used to investigate pairwise differences. Analysis was conducted in Stata 13 and *P*-values less than 0.05 were deemed significant.

Results

There was no evidence of a difference in the number of cycles between groups ($P = 0.71$). However, the number of cycles completed before failure (Table 1) demonstrated that the centurion sandal and multiple looped technique had the lowest failure rates, completing an average of 8.5 and 8 cycles, respectively. The double-loop technique completed an average of 7.5 cycles, while the centurion sandal technique with Steristrips or plastic ties completed an average of 7 cycles. There was evidence of a difference in displacement between groups ($P < 0.01$). The least displacement was in the centurion sandal with plastic ties (average 1 mm). The double-loop technique showed displacement of 2 mm on average; the centurion sandal with Steristrips showed displacement of 2.4 mm on average and the centurion sandal showed displacement of 3.6 mm on

Figure 3 Centurion sandal drain fixation.

average. There was no evidence of a significant difference between the centurion sandal with plastic ties, the double loop, centurion sandal with Steristrips and the centurion sandal alone. However, displacement was highest for the multiple-looped method, with an average of 6.8 mm, which was significantly different from the centurion sandal with plastic ties ($P < 0.01$), the double loop ($P < 0.01$) and centurion sandal with Steristrips ($P < 0.01$). There was no evidence of a statistically significant difference between the multiple-looped method and the centurion sandal ($P = 0.12$). The quickest fixation method to perform by the surgeon was the double loop, with average time of 21 seconds. The centurion sandal took an average of 23 seconds, the centurion sandal with Steristrips took an average of 27 seconds, and the centurion sandal with plastic ties took an average of 28 seconds. The multiple looped method took the longest time, with an average of 33 seconds.

Discussion

Our survey is consistent with another study, which found that the majority of their surgeons used the centurion sandal for chest drain fixation.⁹ The hybrid method of centurion sandal with plastic locking ties was the most secure at

the drain fixation junction, with a displacement of an average of only 1 mm before the suture fractured. We were unable to locate the original description of the centurion sandal (otherwise known as the 'roman sandal' or 'roman garter' or 'lattice' fixation) in the literature, although many modifications of this method have been described.^{5,10} Initial observations of the centurion sandal fixation method in our laboratory showed that it did have a good hold on the drain, which increased when the drain was under a little tension. However, if a centurion sandal suture retracts towards the wound 'like a sock falling down' it loses its security. This can be a result of patient movement postoperatively.

We believe that our hybrid combination of the centurion sandal and the application of two plastic locking ties along its length was superior to the other methods we tested for two reasons. First, it added increased security to the fixation method by snugly applying circumferential tension around the lattice suture against the drain, in two places. Second, it kept the centurion sandal in place and prevented loosening and 'falling down' towards the wound. In comparison to the method described where one tie is used around two loose suture strands, our hybrid has the advantage of using a well-known fixation method, the

Figure 4 Double-loop method.

centurion sandal, with its own merits for drain securement, as well as the positive addition of the ties.⁴ The application of Steristrips to the centurion sandal in our study had an average of 1.4 mm more displacement than the hybrid version with the plastic ties, but performed well for the same reasons as our proposed solution. However, in this experiment, the laboratory area was dry and in the hospital setting it may be exposed to moisture and lose its adhesiveness. The centurion sandal alone fixation method also always failed at the suture site and did not pull through on any cycle; however, it did have some increased displacement compared with the two former methods.

Many of the methods described in the literature are probably enthusiastically used by their authors.^{4,5,11–27} Technical reports are often modifications of existing methods used by surgeons in practice.^{28,29} Although the methods using adhesive methods alone may work well in a hairless, dry operative setting, we were more interested in the securement by suture methods.^{22–24} The aim of many of the studies looking at securing the drain internally, be it through the drain or through the drain holes, were keen to use Prolene® or nylon to avoid the braided silk alternative.^{17–21} There is a question over whether the suture in the lumen of the drain may prevent clots from being

drained in these methods. All the externally based drain fixation methods, except one, use silk, for its quality of increased friction against the external wall of the drain.^{5,11–16} Three methods were inspired by tying methods used in sailing and fishing.^{5,14} In our literature search, we only found one study that subjectively tested postoperative drains by pulling them manually out of a mannequin after their fixation by consultant surgeons and registrars.⁹ Another study did a comprehensive comparative analysis on the pullout force resulting from continuously applied force to five commonly used fixation methods to secure an external ventricular drain, used in neurosurgery in the treatment of hydrocephalus.⁸ The authors extended the study further by testing ten more options by mixing a few methods in the same drain fixation and identified a maximum pullout force of 30 N for the best method. Although there were differences in size, nature and design of the drain in this study, as compared with the drain being tested in our study, this is the only study we found that compared different fixation methods.

A strength of our study is our pragmatic approach, in that the fixation application mimicked real-life intermittent forces on the drain. We concentrated on the interface of the fixation method and the drain itself, removing the

Figure 5 Multiple-loop method.

suture skin interface as an additional factor. However, the findings need to be interpreted in the context of the study's limitations. Our survey was conducted on one site and we only focused on one type of drain. Although this drain is commonly used, it would be interesting to also examine the softer silicone drains.

Clinically, if a surgeon opts to use a surgical drain, it is important for the patient's postoperative course. The tolerance for ingress or falling out of a drain is extremely low. For example, the premature fall out of a drain in the confined area of the neck could lead to dire consequences if a haematoma suddenly developed. Ingression of a drain after a partial hepatectomy would lead to a further operation for its retrieval, in an already compromised patient.² Without further modification and testing, we cannot recommend the use of the double- or multiple-loop methods clinically, owing to full slippage of the drain in our study. Although further clinical studies would be necessary, we feel the addition of the plastic ties to the well-trusted centurion sandal method would reduce any chance of displacement and would add security in the clinical setting. We found that the plastic locking ties we used were cheap, readily available and amenable to sterilisation. The

application of Steristrips to the centurion sandal tie is a recommended alternative in a dry operative site.

Conclusion

Our study increases confidence in the use of the centurion sandal method, especially with the application of plastic ties or in a moisture-free setting, the addition of Steristrips. We would not recommend the double- or multiple-loop method used in this study. Further research is necessary to test our findings in the clinical setting.

Acknowledgement

Fiona Boland, Lecturer in Biostatistics and Research Methods, Royal College of Surgeons in Ireland.

References

1. Schein M. To drain or not to drain? The role of drainage in the contaminated and infected abdomen: an international and personal perspective. *World J Surg* 2008; **32**(2): 312–321.
2. Carlomagno N, Santangelo M, Grassia S *et al*. Laparoscopic retrieval of retained intraperitoneal drain in the immediate postoperative period: report of two cases. *Ann Ital Chir* 2012; **2012**: pii: S2239253X12020208.

Figure 6 Instron 8872® tensiometer.

Figure 7 Evidence of failure with appearance of black dot on the drain.

Table 1 Number of cycles completed before failure.

Method	Average cycles completed before failure <i>n</i> (SD)	Displacement (mm) <i>n</i> (SD)	Rate of full slippage through the fixation suture
CS with tie (<i>n</i> = 10)	7.3 (2.8)	1.0 (1.4)	0/10
CS (<i>n</i> = 10)	8.5 (1.8)	3.6 (3.4)	0/10
CS with Steristrip (<i>n</i> = 10)	7.1 (2.6)	2.4 (2.9)	0/10
Double loop (<i>n</i> = 10)	7.6 (2.2)	2.1 (1.8) ^a	1/10
Multiple loop (<i>n</i> = 10)	8.0 (2.6)	6.8 (2.3) ^b	3/10

CS, Centurion sandal method; SD, standard deviation.
^a*n* = 9.
^b*n* = 7; each cycle exposed the drain to a gradual increase of tension to 30 Newtons. This was repeated until the fixation method failed.

3. Inzirillo F, Giorgetta C, Ravalli E, Della Pona C. 'Roman sandal' modified method for securing the chest drain to the skin. *Gen Thorac Cardiovasc Surg* 2013; **61**(3): 171–173.

4. Melamed E, Blumenfeld A, Lin G. Locking plastic tie: a simple technique for securing a chest tube. *Prehosp Disaster Med* 2007; **22**(4): 344–345.

5. Karunakaran T, Chukwulobelu R, Bulstrode N. A sailor's knot to keep your drain in port. *J Plast Reconstr Aesthet Surg* 2013; **66**(3): e87–88.

6. Kim JC, Lee YK, Lim BS *et al*. Comparison of tensile and knot security properties of surgical sutures. *J Mater Sci Mater Med* 2007; **18**(12): 2,363–2,369.

7. Rutledge LF, DeCabooter DP, Walters SA, Bernatchez SF. Catheter securement systems: comparison of two investigational devices to a sutureless securement device, a securement dressing, and sutures in a pig model. *Intensive Care Med Exp* 2015; **3**(1): 60.

8. Akarca D, Durnford AJ, Ewbank FG *et al*. An evaluation of commonly used external ventricular drain securement methods in a porcine model: recommendations to improve practice. *World Neurosurg* 2018; **110**: e197–e202.

9. Howes RJ, Calder A, Hollingsworth A, Jones A. The end for the 'Roman sandal': an observational study of methods of securing chest drains in a deployed military setting. *J R Nav Med Serv* 2015; **101**(1): 42–46.

10. Whitney NL, Selden NR. Pullout-proofing external ventricular drains. *J Neurosurg Pediatr* 2012; **10**(4): 320–323.

11. Heath DI. Drain fixation with a subcuticular stitch. *J R Coll Surg Edinb* 1987; **32**(4): 242.

12. Hornbrey E, Pandya A, Humzah D. Drain fixation made foolproof. *Ann R Coll Surg Engl* 2000; **82**(4): 290–292.

13. Shokrollahi K. A simple method for securing a surgical drain. *Ann R Coll Surg Engl* 2005; **87**(5): 388.

14. Townley WA, Harley OJ. Securing drains: the clinch knot. *Br J Plast Surg*. 2005; **58**(5): 744–746.

15. Maritz D, McLauchlan C. A novel way to secure a chest drain. *Ann R Coll Surg Engl* 2014; **96**(1): 82.

16. Jategaonkar PA, Yadav SP. Surgical tube-drain: a rapid method of its secure fixation. *J Coll Physicians Surg Pak* 2014; **24**(4): 296.

17. Violaris NS, Chang S, Bridger MW. Securing of suction drains in head and neck surgery. *J Laryngol Otol* 1989; **103**(9): 869.

18. O'Flynn P, Akhtar S. Effective securing of a drain. *Ann R Coll Surg Engl* 1999; **81(6)**: 418–419.
19. Lim PV, Jalaludin MA. An alternative method for securing surgical drains in the neck. *Med J Malaysia* 2000; **55(1)**: 141–142.
20. Lim M, Pitkin L, Spraggs P. A new head and neck surgical drain fixation technique. *J Laryngol Otol* 2005; **119(5)**: 396–397.
21. Judd O, Gaskin J. A simple, cosmetically superior method of securing a post-surgical drain in facial surgery. *Ann R Coll Surg Engl* 2011; **93(2)**: 171.
22. Falconer DT. An alternative method for securing suction drains. *Br J Oral Maxillofac Surg* 1992; **30(2)**: 130–131.
23. Forshaw MJ, Clarke JM. A non-sutured method of drain fixation. *Ann R Coll Surg Engl* 2004; **86(4)**: 308.
24. Finocchi V, Bianciardi Valassina MF, Longobardi G *et al.* Mesentery-like steri-strip: a scarless drain fixation. *Int Wound J* 2016; **13(5)**: 1,020.
25. Jandhyala R, Healy C. A new technique for securing drains to the scalp. *Ann R Coll Surg Engl* 2007; **89(7)**: 726.
26. Clark LA, Clark MH, Ball DR. A simple way of securing drains. *Br J Oral Maxillofac Surg* 2007; **45(7)**: 602.
27. Hoya Y, Okamoto T, Fujita T, Yanaga K. Novel drain fixation device to reduce the peritoneal drain-related complications after gastroenterological surgery. *A N Z J Surg* 2008; **78(12)**: 1,141–1,142.
28. Carter H, Milliken I, Powis MR. Further information on a simple method for securing a surgical drain. *Ann R Coll Surg Engl* 2006; **88(6)**: 607.
29. Hickey SA, Buckley JG, Mitchell DB, O'Connor AF. Securing of suction drains in head and neck surgery. *J Laryngol Otol* 1990; **104(1)**: 69–70.