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Peripheral nerve catheter securement: A narrative literature review

Abstract

Peripheral nerve catheters are commonly used to provide analgaesia and improve patient outcomes. Catheter dislodgment, displacement or leakage can result in premature cessation of analgaesic effect. There are currently no published guidelines for how to secure peripheral nerve catheters.

This narrative review explores and integrates the available research into the efficacy of peripheral nerve catheter securement products and techniques to reduce catheter dislodgement and displacement.

All studies looking at peripheral nerve catheter securement methods were included from inception until 19 October 2022 across PUBMED, Scopus, Ovid, Google Scholar, EMBASE and The Cochrane Library. The Jadad scale and Newcastle–Ottawa scale were used to assess the methodological quality of randomised controlled trials and observational studies, respectively.

Sixteen papers were included in this review. The results were mixed and substantial heterogeneity across studies further limited the ability to draw firm or generalisable conclusions. Rather, several products and techniques that may reduce catheter dislodgement, displacement or leakage, that can contribute to dislodgement, were identified for further investigation. There was some evidence to support the use of the catheter over needle technique, adhesive dressings and tissue adhesives. The number of studies investigating subcutaneous tunnelling and anchoring devices was particularly limited.

Keywords: regional anesthesia, analgesia, nerve block, catheters

Introduction

Continuous or programmed intermittent peripheral nerve blockade involves the percutaneous insertion of a catheter near a peripheral nerve or plexus, or into a fascial plane where nerves are known to travel, followed by the administration of local anaesthetic. This technique is frequently used to provide post-operative analgaesia and results in sustained analgaesia, decreased opioid use and reduced length of hospital stay.[1]

Despite the many benefits that continuous peripheral nerve blocks offer they are not without their drawbacks. A common problem encountered with this procedure is inadequate catheter securement resulting in catheter dislodgement (complete inadvertent catheter removal) or displacement (migration from target).

The risk of catheter dislodgment after a procedure varies depending on catheter location. Dislodgement rates have been reported at five per cent for interscalene catheters and as high as 25 per cent for femoral catheters.[2] The benefits of peripheral nerve blocks depend on the catheter remaining in place and, as such, dislodgment results in inadequate analgaesia and requires the catheter to be reinserted correctly. Minimising peripheral nerve catheter dislodgment and displacement is desirable from both patient safety and economic perspectives.[3]

Despite continuous peripheral nerve blocks being frequently used, and the risk of catheter dislodgment or displacement being a common complication, there are currently no guidelines detailing how to optimally secure a peripheral nerve catheter. This narrative review explores the available research into the efficacy of peripheral nerve catheter securement products and techniques with the aim of decreasing dislodgment and displacement rates.

Methods

The following literature databases were reviewed for information about peripheral nerve catheter securement: PUBMED, Scopus, Ovid, Google Scholar, EMBASE and The Cochrane Library. Search terms consisted of free text keywords such as 'perineural catheter securement', 'peripheral catheter securement', 'perineural catheter fixation', 'peripheral catheter fixation', 'catheter securement' and 'catheter fixation'. Specific terms, such as 'intravenous', 'urinary', 'arterial' and 'vascular' were excluded from the search. All literature found through this search strategy was included from inception until 19 October 2022.

The quality of randomised controlled trials was assessed using the Jadad scale.[4] This scale evaluates randomisation, blinding and withdrawal or drop out, and rates studies on a scale from 0 (very poor) to 5 (excellent). The quality of observational studies was assessed using the Newcastle–Ottawa scale.[5] This scale evaluates subject selection, subject comparability and assessment of exposure or outcome, and rates studies on a scale from 0 (poor quality) to 9 (good quality).

Results

A total of 16 papers were included in this narrative review – ten randomised control studies, one retrospective review, one quality improvement cycle, two nonrandomised controlled studies and two for which the design was not stated. Seven papers investigated catheter insertion techniques, namely catheter through needle (CTN) and catheter over needle (CON).

Inserting a catheter using the CON technique resulted in significantly decreased pericatheter leakage, dislodgment rates and significantly increased force required to dislodge a catheter in the majority of studies. A cadaveric study found that a CTN technique reduced displacement, but the remaining six studies did not report any benefit of using the CTN technique compared to the CON technique in regard to leakage, dislodgement or force required to remove a catheter. A summary of these results and a quality assessment of the literature can be found in Table 1.

Three papers investigated subcutaneous tunnelling of catheters. Subcutaneously tunnelling a catheter resulted in significantly decreased catheter dislodgment rates and significantly increased force required to remove a catheter compared to untunnelled catheters. No studies found any benefit in using an untunnelled catheter in regard to dislodgment rates or force required to remove a catheter. A summary of these results and a quality assessment of the literature can be seen in Table 2.

One article investigated the use of an anchoring device as a securement method. The use of an anchoring device significantly increased the force required to remove a catheter. A summary and quality assessment of this study can be seen in Table 3.

Five papers investigated the use of adhesive dressings, adhesive strips or tissue adhesives as securement methods. The use of tissue adhesive and transparent dressing resulted in significantly reduced catheter tip displacement and pericatheter leakage. The use of these techniques also resulted in decreased catheter dislodgment; however, the study that reported this finding did not state the statistical significance of this result. No study showed any benefit in not using tissue adhesive or a transparent dressing with regard to catheter tip dislplacement, pericatheter leakage or catheter dislodgment. A summary of these articles and a quality assessment of the literature is presented in Table 4.

Discussion

Peripheral nerve blocks are widely used to provide sustained post-operative analgaesia and minimising the risk of accidental dislodgment is essential to their efficacy. Accordingly, a wide range of catheter securement products and techniques that may minimise the risk of dislodgement are available.

Placement technique

The traditional method of peripheral nerve catheter insertion involves placing a needle in close proximity to the peripheral nerve, plexus or fascial plane of interest and then feeding a catheter through the needle. A novel approach has since been developed which involves placing a catheter over the needle, placing this near the target, and then removing only the needle. As the catheter is the same size as the needle puncture, there should be a tighter seal that is theorised to decrease the rate of catheter dislodgement.[6,12]

Table 1: Summary of results of studies comparing catheter through needle (CTN) and catheter over needle (CON) techniques

Study	Study design	Type of block	Participant surgery/block or study model	Number of participants/ trials	Catheter securement methods	Results	Jadad scale score
Edwards et al.[6]	RCT	femoral nerve block or adductor canal block	total knee arthroplasty	110 patients	CON and CTN both with adhesive dressing*	Significantly lower dislodgement rate with CON (p < 0.01). No significant difference in leakage rate.	3/5
Ip et al.[7]	RCT double-blinded	interscalene brachial plexus block	shoulder surgery	10 patients	CON and CTN	Leakage and displacement exclusively with CTN catheters but statistical significance of difference not evaluated due to small sample size.	4/5
Kim et al.[8]	RCT double-blinded	femoral nerve block	total knee arthroplasty	65 patients	CON and CTN both with adhesive dressing**	Significantly lower leakage rate with CON (p < 0.01). No significant difference in dislodgement rate.	5/5
Nogawa et al.[9]	RCT	femoral nerve block	total knee arthroplasty	40 patients	CON vs CTN, both with adhesive dressing**	Significantly lower leakage rate with CON (p < 0.01).	2/5
Steffel et al.[10]	RCT double-blinded	popliteal sciatic nerve block	cadaver	15 trials per group	CON and CTN both with adhesive dressing***	Significantly lower rate of displacement from nerve compartment with CTN catheters (p = 0.04) No significant difference in dislocation.	5/5
Tanijima et al.[11]	Retrospective review	interscalene brachial plexus block	interscalene brachial plexus block using CON method	122 patients	CON with adhesive dressing** and tissue adhesive****	No instances of leakage.	N/A
Tsui & Tsui[12]	NRCT	N/A	porcine	160 trials per group	CON and CTN	Significantly greater force required to dislodge CON catheters (p < 0.001). Significantly higher injection pressure without leakage with CON catheters (p < 0.001).	N/A

RCT = randomised controlled trial, NRCT = nonrandomised controlled trial, CON = catheter over needle, CTN = catheter through needle
** Tegaderm™ or Opsite™ ** Tegaderm™ *** Bioclusive™ **** Dermabond™*

Table 2: Summary of results of studies comparing tunnelled catheters and untunnelled catheters

Study	Study design	Type of block	Participant surgery/block or study model	Number of participants/ trials	Catheter securement methods	Results	Jadad score
Bryne & Freeman[13]	NRCT	N/A	porcine	13 trials per group	double tunnelled, tunnelled and untunnelled catheter	Double tunnelling significantly increased the force needed to dislodge catheter (p <0 .001)	N/A
Compere et al.[14]	RCT, single blinded	femoral nerve block	knee or femur surgery	338 patients	untunnelled catheter with adhesive strips* and tunnelled catheter with adhesive dressing*	Significantly lower dislodgement rate with tunnelled catheter (p = 0.02) Significantly lower bacterial colonisation rate with tunnelled catheter (p = 0.02)	5/5
Leng et al.[15]	RCT, blinded	adductor canal block	cadaver	5 trials per group	untunnelled flexible, untunnelled rigid, tunnelled flexible and tunnelled rigid, all with adhesive dressing**	No significant difference in displacement or dislodgement rates.	5/5

NRCT = nonrandomised controlled trial, RCT = randomised controlled trial
**Steri-Strips™ ** Bioclusive™*

Table 3: Summary of results of study comparing tunnelled catheters with and without an anchoring device

Reference	Study design	Type of block	Study model	Number of participants/trials	Catheter securement methods	Results	Jadad score
Borg et al.[18]	RCT, blinded	N/A	cadaver	10 trials per group	Anchoring device (StatLock™) and no anchoring device both with adhesive dressing (Tegaderm™)	Significantly greater force required to dislodge catheters using StatLock™	3/5

RCT = randomised controlled trial

Table 4: Summary of results of studies investigating adhesive dressings, adhesive strips and tissue adhesives

Reference	Study design	Type of block	Participants	Number of participants	Catheter securement methods	Results	Jadad or NOS score
Auyong et al.[20]	RCT, double blinded	interscalene brachial plexus block	patients undergoing total shoulder arthroplasty or open reduction and internal fixation of a proximal humerus fracture	63	Tissue adhesive Dermabond™ and tissue adhesive Mastisol™ both with adhesive dressing (Opsite™)	Significantly lower catheter displacement distance with Dermabond™ (p < 0.001). Significantly lower leakage rate with Dermabond™ (p < 0.001)	5/5
Chalacheewa et al.[21]	RCT	femoral nerve block	patients undergoing total knee arthroplasty	30	Tissue adhesive (Dermabond™) and adhesive strips (Steri-Strips™) both with adhesive dressing (Tegaderm™).	Significantly lower displacement rate with Dermabond™ (p <0.001) Significantly lower leakage rate with Dermabond™ (p <0.001). No significant differences in dislodgement rates.	3/5
Gurnaney et al.[1]	Quality improvement cycle	not stated	patients requiring continuous perineural infusion	1644	Adhesive dressing alone and adhesive dressing with tissue adhesive (Dermabond™)	Fewer instances of leakage and dislodgement with Dermabond™ but statistical significance of difference not evaluated.	4/9
Kumar et al.[22]	Not enough information to ascertain	N/A	volunteer participants	6	Adhesive dressing* alone, adhesive dressing with tissue adhesive**, adhesive dressing with tissue adhesive and parallel*** Steri-Strips™, adhesive dressing with tissue adhesive and perpendicular**** Steri-Strips™, adhesive dressing with tissue adhesive, topical benzoin and parallel*** Steri-Strips™, adhesive dressing with tissue adhesive, medical adhesive spray (Adapt™) and parallel*** Steri-Strips™	Significant difference between groups (p < 0.001), combination of adding SwiftSet™, Steri-Strips™ and Adapt™ required to significantly increase force required to dislodge catheter.	N/A
Tsui et al.[23]	Not enough information to ascertain	N/A	volunteer participants	31	Single and double layer of adhesive dressing (Tegaderm™)	Significantly greater force required to dislodge catheters with double layer (p <0 .001)	N/A

RCT = randomised controlled trial, NOS = Newcastle–Ottawa scale
** transparent adhesive dressing Tegaderm™ was used on all participants in this study*
*** tissue adhesive SwiftSet™ was used on all participants in this study*
**** placed parallel to the long axis of the catheter*
***** placed perpendicular to the long axis of the catheter*

Tsui and Tsui[12] demonstrated that a significantly greater amount of force was required to dislodge a catheter placed using the CON technique compared to a catheter inserted using the CTN technique in porcine models. Steffel et al.[10] found lower rates of dislocation of the catheter from the nerve compartment associated with the CTN technique compared to the CON technique in a cadaver model when both were placed under an adhesive. However, the transferability of these results from a cadaver model to living tissue is uncertain.

Indeed, differing results were found in living participants. One study of femoral nerve and adductor canal blocks[6] found a significantly lower rate of catheter dislodgement with the CON technique compared to CTN technique when both were secured under an adhesive dressing, while another study of femoral nerve blocks[8] found no significant differences in rates of dislodgement when comparing these techniques.

A number of studies[8,9,12] have also found the CON technique to be associated with decreased leakage of anaesthetic, which may in turn decrease the chance of catheter dislodgment. In contrast, however, Edwards et al.[6] did not find any significant difference in leakage rates between these techniques. It is important to note that, while not all studies found significant improvements using the CON technique, there were no indications that the CTN technique was superior in reducing rates of dislodgment or leakage.

The use of a CON insertion method appears to be the most researched technique in the currently available literature and there is some evidence to suggest that it may be useful in reducing dislodgement rates, increasing the force required to dislodge a catheter or increasing resistance to leakage that can disrupt securement, compared to the CTN technique.[6,8,9,12]

Subcutaneous tunnelling

Subcutaneous tunnelling involves having a few centimetres of the catheter subcutaneously embedded proximal to the insertion site which may minimise the risk of dislodgment by reducing drag on the catheter.[13,16] Byrne and Freeman[13] compared single-tunnelled, double-tunnelled and untunnelled catheters and found that the force to remove a double-tunnelled catheter was significantly greater than the force required to remove an untunnelled one in porcine models, although it is not clear whether a single-tunnelled catheter conferred this same benefit. Further, the use of porcine models may limit the transferability of these results to humans.

A second study by Leng et al.[15] investigated the dislodgment and dislocation rates of tunnelled and untunnelled catheters inserted in a cadaver and did not find significant differences between these techniques. However, there are several limitations including the difference in tissue mechanics between cadavers and living patients and the possibility that the study was underpowered to detect a significant difference.

A study by Compere et al.[14] in living patients demonstrated that tunnelled catheters secured with an adhesive dressing were associated with a lower rate of dislodgement compared to untunnelled catheters secured with adhesive strips, although the differences in adhesives used (i.e. dressings versus strips) impairs the ability to make direct comparisons on the effect that tunnelling has on the risk of dislodgement.

The currently available evidence regarding the benefits of tunnelling in reducing catheter dislodgement is limited and complicated by the use of porcine and cadaver models, differences in tunnelling, and differences in use of additional adhesive dressings or adhesive strips in the available literature. The effects on dislodgement remain unclear at this time but it is possible that this technique confers other benefits such as reducing infection or bacterial colonisation, which may be of particular importance when catheters are to remain in place for a longer duration.[14,17,24]

Catheter fixation devices

The use of catheter fixation devices has also been explored as an additional catheter securement method, although the available evidence in the context of peripheral nerve catheters specifically is extremely limited. Borg et al.[18] found that the force required to disrupt or dislodge an adhesive dressing was significantly higher when an anchoring device was used compared to an adhesive dressing alone. However, as the study used a cadaver, the transferability of these results to living patients is unclear.

More importantly, the study did not use a catheter in the experiment due to methodological limitations, and instead reports on the forces required to disrupt an adhesive dressing over a catheter connector. As such, results with an inserted peripheral nerve catheter may differ, although these findings suggest that an anchoring device may confer additional resistance to dislodgement in instances where a catheter connector is used. There is greater evidence for the employment of fixation devices, particularly those placed at the catheter insertion site, within the epidural literature, and further evaluation in the context of peripheral nerve catheters is required.[3,19]

Dressing and adhesives

Adhesive dressings, adhesive strips and tissue adhesives have also been explored in various combinations and as adjuncts to CON or CTN catheter placement and tunnelled or untunnelled catheters. A recent study by Chalacheewa et al.[21] found that the use of a topical skin adhesive resulted in significantly decreased catheter leakage and displacement, but not dislodgement, compared to sterile strips when both were applied under an adhesive dressing. Similarly, a quality improvement cycle conducted by Gurnaney et al.[1] noted fewer instances of leakage and dislodgment when a tissue adhesive was used in conjunction with an adhesive dressing compared to a dressing alone, but the statistical significance of this result was not reported.

In contrast, Kumar et al.[22] found that neither the addition of a tissue adhesive nor a tissue adhesive with adhesive strips increased the force required to dislocate a catheter compared to the use of an adhesive dressing alone. However, the addition of a combination of tissue adhesive, adhesive strips and medical spray adhesive to the dressing was found to significantly increase the force required. Further research is required to evaluate the possibility that tissue adhesives confer superior catheter securement than adhesive dressings used alone or adhesive dressings used in conjunction with sterile strips.

Likewise, comparison of products or the manner in which they are used is warranted. Auyong et al.[20], for example, compared two skin adhesives, and found that Dermabond™ was associated with lower leakage and displacemnt rates than Mastisol™ when both were used in conjunction with an adhesive dressing. Tsui et al.[23] also explored a novel technique of catheter securement wherein two layers of Tegaderm™ (one applied directly to the skin and a second applied over the catheter) significantly increased the force required to dislodge the catheter compared to taping the catheter directly to the skin with a single layer of Tegaderm™. However, as the catheters were simply taped onto the skin, results may be different for inserted peripheral nerve catheters.

Tentatively, there may be some evidence to support the use of adhesive dressings and tissue adhesives to improve catheter securement[14,21,22]; however, it is not possible to draw firm conclusions due to the wide range of available products and limited direct comparisons.

Literature limitations

It is also important to highlight the limited number of available studies and their varying degrees of methodological rigour when drawing conclusions regarding optimal catheters securement. For example, Ip et al.[7] have several discrepancies from the registered protocol; as such, the data may not be trustworthy. Additionally, the trial of Kim et al.[8] started before the protocol was registered, also representing a significant bias for the results.

Further, the generalisability of findings from the currently available literature may be impacted by significant heterogeneity such as differences in peripheral nerve block types or locations (e.g. femoral, adductor canal, interscalene). Results may be impacted by differences in the tissues used, the distance the catheter needs to travel to be in close proximity to the nerve and the degrees of force applied to the catheter. Movements of the hip, for example, transfer more directly to the femoral nerve catheter than shoulder movements do to the interscalene nerve catheter.[2] As such, it is possible that the variability in these characteristics between nerve block locations may require different securement methods.

Conclusion and recommendations

Peripheral nerve catheters are frequently employed to provide post-operative analgaesia and improve patient outcomes. Dislodgement or displacement of a perineural catheter represents the premature cessation of planned analgaesia and potentially the loss of any improvement in outcomes. The large volume of published literature dealing with regional analgaesia optimisation has largely ignored catheter securement as a method to improve regional analgaesic outcomes. In this narrative review we found a limited number of studies that addressed catheter, adhesive and dressing characteristics to guide clinicians. The limited evidence that is available most strongly supports the use of the CON placement technique, adhesive dressings and tissue adhesives.

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