(Acta Anaesth. Belg., 2020, 71, 95-100)

Knotted epidural catheter: the role of determining a catheter's ultimate tensile strength before pulling on it. A case report and literature review

A. Orfi (*), P.Y. Dewandre (**), J.F. Brichant (**)

Abstract : Knotting is a well-known but rare complication of the use of epidural catheters. We report the case of a knotted catheter successfully removed by simple traction, after determining its ultimate tensile strength. We reviewed the case reports published since 1979. We assessed the prevalence of this complication, the impact of placement technique on a knot's occurrence, the value of the different imaging modalities, and the one of various techniques used for catheter removal. A knotted catheter can often be removed intact with steady and gentle traction. Before pulling on an entrapped catheter and to avoid breakage, it may be useful to assess its ultimate tensile strength on its free extremity or another identical catheter. Limiting the length of a catheter threaded in the epidural space during its insertion seems to be the best way to avoid knots.

Keywords : Knot ; epidural catheter ; labor analgesia ; knotted catheter ; adverse effects.

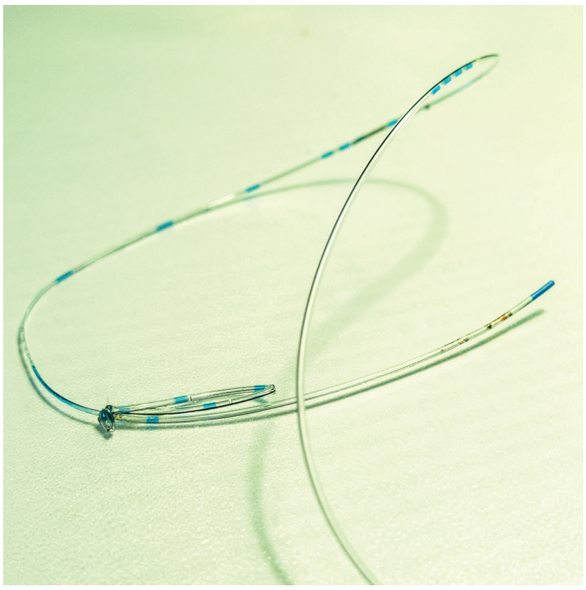

Fig. 1. — The knot is at 90 mm from the tip.

Introduction

Knotting of an epidural catheter is a very rare complication, with an estimated prevalence of 0,0015% (1). We report a case of a double looped and knotted lumbar epidural catheter, successfully removed without surgery. In Addition, we have conducted an exhaustive literature review, analyzing all cases of knotted epidural catheter reported in adults since 1979.

Case report

A 28 year-old woman, Gravida 1, Para 0, with no significant medical history records, was admitted for early labor at 40 week pregnancy. She rapidly requested epidural analgesia for her labor pain. The epidural catheter (Perifix® set, 18-gauge Thuoy needle, 20-gauge catheter, B. Braun Melsungen AG, Germany) was inserted at the first attempt, using a median approach at L3-L4 lumbar space and the loss of resistance to saline technique. Epidural space was reached at 55 mm, and the catheter was threaded easily beyond 200 mm mark at the proximal hub of the needle. Pulling out the epidural catheter to the optimal length before fixation led to its entrapment, with the 15cm mark at the skin.

We approximated the catheter's ultimate tensile strength (UTS), i.e the maximum stress that a catheter can withstand while being stretched or pulled before breaking, by manually stretching its free extremity (the part of the catheter over the 200 mm mark) until breakage. Steady and gentle traction was then applied on the catheter's entrapped part after placing the patient in the same position

Annis Orfi, MD ; Pierre-Yves Dewandre, MD ; Jean François Brichant, MD, PhD.
(*) Department of Anesthesia, Groupe Hospitalier Artois-Ternois, Arras, France
(**) Department of Anesthesia & ICM, CHU Liège, 4000 Liege, Belgium
Corresponding author : Annis Orfi, Department of Anesthesia, Groupe hospitalier Artois-Ternois, Arras, France.
E-mail : annis.orfi@outlook.com

Paper submitted on Apr 29, 2019 and accepted on Jan 24, 2020
Conflict of interest: None

Fig. 2. — Enlarged view of the knot, showing the double loop.

as during insertion – sitting at the bedside. This technique enabled catheter mobilization, and once the knot was felt under the skin, a 5mm incision allowed its removal. The Catheter was intact and not sheared, but with a double loop and knot at 90mm from its tip (Fig. 1 and 2).

The placement of a new catheter was performed at the same lumbar space (L3-L4) by the same anesthesiologist with an identical epidural set (Perifix® set, 18-gauge Thuoy needle, 20-gauge catheter, B. Braun Melsungen AG, Germany). Epidural space has been reached at 55mm, and the catheter was fixed with 110mm mark at the skin.

After injection of the local anesthetic solution, the patient reported effective pain relief during the entire labor. The catheter was easily withdrawn by the nurse anesthetist approximately 2 hours after uneventful delivery. No paresthesia nor other neurological symptoms arose during her hospital stay.

Informed Consent

The patient has been informed about the publication of the case report and has given her written consent.

Discussion

Using the keywords "knot*" and "epidural catheter", the MEDLINE, BASE, and SCOPUS databases were searched for relevant articles and case reports published since 1979, without language restriction. Additional searches were performed by checking the reference lists of all articles manually, as detailed in the flow chart (Fig. 3). Case reports were included if they met the inclusion criteria - published case reports of knotted epidural catheter in adults, excluding trapped, sheared or broken catheters without evidence of a knot. The article selection for the comprehensive review was based upon the authors' assessment of the relevance to the topic.

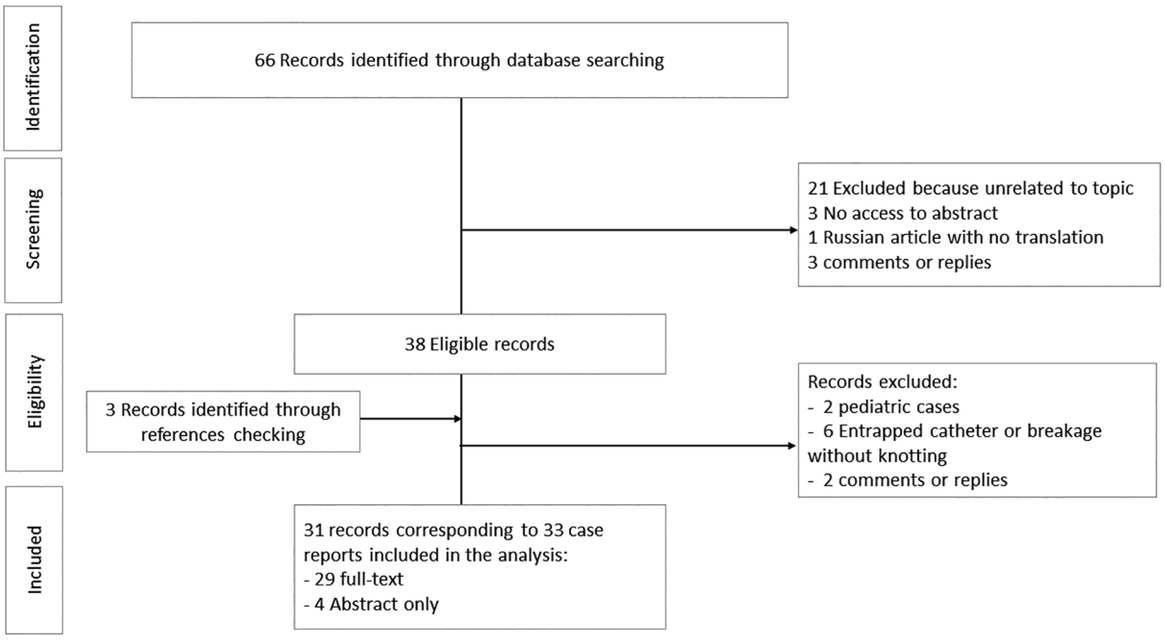

Fig. 3. — Literature review FLOW chart

Table 1

Case reports of knotted epidural catheter in adults, since 1979.

Author	Year	Language	Article type	Gender	Age	Reason	Level	Epidural placement technique	Distance at skin (mm)	Knot at (mm)	Rescue technique	Medical imaging	Catheter brand	Outcome	Frequency
Browne (16)	1979	EN	Complete	F	22	Obstetric	L2-L3	Saline LOR	150	29	None	X-ray	Portex	Out	
Blass (17)	1981	EN	Letter	F	24	Obstetric	L3-L4	NA	NA	NA	Surgery	X-ray	NA	Out	
Riegler (18)	1983	GER	Abstract	F	NA	Obstetric	L2-L3	NA	NA	NA	Surgery	X-ray	NA	NA	
Saderski (19)	1988	EN	Letter	F	NA	Obstetric	L2-L3	NA	NA	4	None	X-ray	Theracath	Out	
Fibuch (5)	1990	EN	Letter	F	32	Obstetric	L3-L4	NA	NA	<10	None	None	Theracath	Out	1 of 65140
Striebel (20)	1991	GER	Abstract	F	NA	Obstetric	lumbar	NA	NA	NA	None	X-ray	NA	Out	
Gozal (21)	1996	EN	Abstract	F	24	Obstetric	lumbar	NA	NA	NA	GA	NA	NA	NA	
Gozal (21)	1996	EN	Abstract	F	28	Obstetric	lumbar	NA	NA	NA	None	NA	NA	NA	
Folk (6)	2000	EN	Complete	F	46	Surgery	L3-L4	Saline LOR	NA	5	None	None	Kendall	Out	1 of 20000
Renehan (22)	2000	EN	Complete	F	37	Obstetric	L2-L3	Air LOR	110	37	Surgery	X-ray	Portex	Out	
Hsin (23)	2001	EN	Complete	M	30	Surgery	T8-T9	Air LOR	NA	39	None	X-ray	Braun	Out	
Damhieu (24)	2002	EN	Complete	F	27	Obstetric	L3-L4	Air LOR	130	20	Surgery	CT	Braun	Out	
Dounas (3)	2002	FR	Complete	F	19	Obstetric	L2-L3	Saline LOR	NA	NA	Surgery	CT	portex	Left in situ	
Karraz (25)	2002	EN	Letter	F	27	Obstetric	L2-L3	NA	NA	25	None	None	NA	Out	
Macfarlane (2)	2002	EN	Complete	F	24	Obstetric	L2-L3	Air LOR	95	10	Pull day 4	None	Abbott	Out	1 of 21000
Gabopoulou (26)	2005	EN	Letter	F	75	Surgery	L2-L3	NA	110	100	Surgery	X-ray	NA	Out	
Brichant (1)	2006	EN	Complete	F	28	Obstetric	lumbar	Air LOR	100	4	None	None	Braun	Out	1 of 25000
Elsharydah (27)	2006	EN	Letter	F	77	Surgery	L1-L2	NA	120	30	None	X-ray/CT	Arrow	Out	
Arnaoutoglou (28)	2007	EN	Complete	F	28	Obstetric	L2-L3	Air LOR	NA	10	None	None	portex	Out	
Alkayed (29)	2008	EN	Complete	F	26	Obstetric	L3-L4	Saline LOR	120	60	Surgery	None	Portex	Out	
Breget (11)	2008	FR	Complete	F	33	Obstetric	L2-L3	NA	150	NA	Surg. day 3	MRI/CT	Braun	Out	
Breget (11)	2008	FR	Complete	F	29	Obstetric	L3-L4	NA	200	NA	Surg. day 17	CT	Braun	Out	
Garcia-saura (30)	2008	ESP	Letter	F	NA	Obstetric	L2-L3	NA	NA	5	Sedation	X-ray/CT	NA	Out	
Esquedaarriaga (31)	2009	ESP	Complete	M	19	Surgery	L2-L3	NA	NA	35	Surgery	None	NA	Out	
Chang (4)	2010	EN	Complete	F	75	Surgery	L3-L4	Air LOR	170	50	Surgery	None	Portex	Out	1 of 26300
Huang (32)	2010	EN	Letter	F	39	Obstetric	L3-L4	Saline LOR	NA	75	None	None	Braun	Out	
Fischer (8)	2011	FR	Complete	M	43	Surgery	T3-T4	Saline LOR	140	13	None	None	Braun	Out	1 of 3400
Lala (33)	2011	EN	Letter	F	29	Obstetric	L3-L4	Saline LOR	110	10	None	None	NA	Out	
Singh (34)	2015	EN	Letter	F	29	Obstetric	L3-L4	NA	NA	65	GA	CT	NA	Out	
Yallapragada (35)	2015	EN	Complete	M	30	Surgery	L4-L5	NA	90	5	Surgery	None	NA	Out	
Baer (36)	2017	SWE	Abstract	F	30	Obstetric	Lumbar	NA	NA	NA	None	None	NA	Out	
Molina-Garcia (37)	2017	ESP	Complete	F	25	Surgery	L2-L3	Air LOR	140	10	surgery	none	NA	Out	
Park (38)	2017	EN	Complete	F	73	Pain clin.	C6-C7	NA	100	15	none	none	Smiths	Out	

EN : English, SWE : Swedish, GER : German, ESP : Spanish, FR : French. NA : not available, M : Male, F : Female, GA : General anesthesia.

To date, 33 cases have been reported in adults since 1979. The main characteristics are reported in Table 1. Most catheters were placed at lumbar level and 76.6% were inserted for obstetric analgesia. All knots formed within 100mm of the tip, but 33% of the knots occurred within 10mm of the tip, suggesting a looping of the catheter immediately after exiting from the Tuohy needle. The catheter's inserted length, when the knot was discovered during placement, ranged from 90 to 200 mm but was inconsistently reported. Eighteen of the 33 knotted catheters (54%) were successfully removed by traction only, one being removed after 4 days of multiple daily pulling attempts (2). In two other cases traction under general anesthesia or deep sedation allowed retrieval of the catheter.

Thirteen patients underwent various surgeries, from Ligamentum flavum fenestration to full laminectomy. The surgery delay ranged from a few hours to 17 days of catheter insertion. In only four cases surgery was subsequent to catheter breakage. In the 9 other cases, the catheter was entrapped but still intact. Ironically, in one case the catheter breakage was due to surgery itself, and the catheter fragment was finally left in situ (3). To note, only one patient out of the 13 had neurological symptoms before surgery.

Several techniques for withdrawal of entrapped epidural catheter were described in literature, as summarized in table 2.

Prevalence

The prevalence of knotted catheters at lumbar level ranged from 1/20.000 to 1/65,140 (0.0015 to 0.005%) (1,2,4-6).This prevalence remained unchanged over the last 40 years.

Regarding knots at thoracic level, the prevalence reported by Fischer F. et al. (8) (1/3400) seems very high, which is quite unexpected especially when considering that anatomically epidural catheters at thoracic level are less prone to knotting – due to the lower frequency of meningovertebral ligaments compared to the lumbar region (7). These figures have not been confirmed by other publications.

Table 2

Previously described techniques for withdrawal of entrapped epidural catheter

1. Progressive increase of traction force (33).
2. Slow and gentle traction by attaching a weight on the free extremity of the catheter (a stapler of 100 g) (39).
3. Saline injection and Positive pressure through an air-filled tuberculin syringue (40).
4. Lateral positioning of patient (9).
5. Placing the patient in the same position for removal as for insertion (41).
6. General anesthesia + neuromuscular blockade before traction on the catheter (40, 42).
7. Surgical removal by neurosurgeon (4).

Patient's position

The importance of patient positioning is unclear. According to Boey (9), lateral positioning allowed a 2.5N reduction of force needed to withdraw the epidural catheter, in the median and paramedian approach. In a more recent study by Michalek (10), forces needed to withdraw lumbar spinal catheters were unrelated to patient height, weight, sex, or age, patient position during catheter removal, and length of catheter under the skin or in the subarachnoid space. Also withdrawal forces were similar whether patients were in the flexed lateral - 95% CI (0.73, 1.34) – or in sitting position - 95% CI (0.59, 0.97) – during spinal catheter removal. Given that Boey's study was conducted in 1994, that both studies used B. Braun catheters, and considering newly available data, it might be reasonable to reconsider the importance of patient positioning. There is no evidence supporting a change in the patient's position if insertion was easy and successful.

Medical imaging value

Medical imaging was used in 50% of the cases, predominantly X-ray and Computed tomography (CT). Imaging was of little value on most cases, even when the knot was identified. In one case the patient had a CT, Ultrasound, and an MRI. Only CT allowed the visualization of the whole catheter and the knot (11). Bréget et al. stated that MRI did not outperform the CT imaging. This was the only case reporting MRI use. Based on available data, we suggest no imaging at first stage in the absence of neurological symptoms and advise performing a CT if a catheter fragment must be left in-situ, or in case of planned surgery.

Catheter & placement technique

The catheter itself does not seem to be an important risk factor. Knots occurred with catheters of various manufacturers. The almost unchanged prevalence over the last 40 years might be due to improvements in catheters design, or simply publication bias.

Regarding the placement technique, no strong conclusion can be drawn owing to the lack of information in most reported cases.

Interestingly, Gehan et al. (12) reported the case of an uneventful follow-up after an epidural catheter breakage and retrieval of the abandoned fragment on a CT imaging 8 years later – at the same location with no complication during that period.

Ultimate tensile strength

A study by Ates et al. (13) compared the UTS of various intact and traumatized epidural catheters in laboratory conditions. The intact polyurethane catheters are more durable to tensile loading than radio-opaque and nylon catheters. These catheters handled more than 50 Newton load. They stretched by more than 300% of their original length without breaking. As expected, traumatized catheters broke at loads and elongation levels much smaller than intact ones. More recently, Gonsalez et al. (14), assessed the tensile strength of reinforced catheters made of 3 different materials (polyurethane, Pybax nylon and polyamide nylon), and under various conditions - at room temperature, after the removal of the inner wire, injection of normal saline, and at 37 ± 1°C. They confirmed that polyurethane catheters are the most durable. Furthermore, polyurethane and pybax nylon catheters showed no variation in tensile strength with temperature, when the tensile strength of polyamide nylon catheters decreases at 37 ± 1°C. In their study comparing tensile strength of 19- and 20-gauge epidural reinforced catheters at 22 and 37° Celsius (polyurethane FlexTip Plus® epidural catheter, Arrow® International, Reading, PA, USA), Tsui BC. and Finucane B. found no significant difference at either temperature (15).

In our case, approximating the catheter's UTS allowed us to use the right strength when pulling out the catheter, without risking its breakage. The loop and knot were certainly due to the length of catheter threaded in the epidural space during its placement - 200-250mm at skin. Limiting that length is more important than limiting the one left inside the epidural space. As stated by many authors, threading the catheter more than 50mm beyond needle tip is a great risk factor for its looping and knotting.

Conclusion

Knotted catheters can often be removed intact with steady and gentle traction. To avoid a catheter breakage and therefore a potential surgical procedure, testing and determining the catheter's UTS on its free extremity, or on another identical catheter, before pulling on the entrapped part is advisable. The best way to reduce the risk of knotting is to limit the length of catheter threaded in the epidural space during its placement, and not only the length of catheter left in the epidural space. Ultimately, surgery should be discussed only if neurological symptoms occur.

References

1. Brichant JF, Bonhomme V and Hans P. 2006. On knots in epidural catheters: a case report and a review of the literature. Int J Obstet Anesth. 15(2):159-162.
2. Macfarlane J and Paech MJ. 2002. Another knotted epidural catheter. Anaesth Intensive Care. 30(2) : 240-243.
3. Dounas M, Peillon P, Lebonhomme JJ and Guittard Y. 2002. Difficultés de retrait puis rupture d'un cathéter péridural. Ann Fr Anesth Réanim. 21 : 600-602.
4. Chang P-Y, Hu J, Lin Y-T, Chan K-H and Tsou M-Y. 2010. Butterfly-like Knotting of a Lumbar Epidural Catheter. Acta Anaesthesiol Taiwan. 48 : 45-48.
5. Fibuch EE, Mcnitt JD and Cussen T. 1990. Knotting of the Theracath™ after an Uneventful Epidural Insertion for Cesarean Delivery. Anesthesiology. 73 : 1293.
6. Folk JW, Joye TP, Duc TA and Bailey MK. 2000. Epidural catheters: the long and winding road. South Med J. 93 : 732-733.
7. Jiang H, Shi B and Xu S. 2015.An anatomical study of lumbar epidural catheterization. BMC Anesthesiol [Internet]. Available from: http://bmcanesthesiol.biomedcentral.com/articles/10.1186/s12871-015-0069-x
8. Fischer F, Helms O, Hentz J-G and Steib A. 2011. Nœud dans un cathéter péridural thoracique. Ann Fr Anesth Réanim. 30 : 153-155.
9. Boey SK and Carrie LES. 1994. Withdrawal forces during removal of lumbar extradural catheters. Br J Anaesth. 73 : 833-835.
10. Michalek-Sauberer A, Oehmke MJ, Scharbert G, Neumann K, KozekLangenecker SA and Deusch E. 2008. Withdrawal forces of lumbar spinal catheters: no dependence on body position. Br J Anaesth. 100 : 846-849.
11. Bréget J-M, Fischer C, Ben Meftah R and Tabary N. 2008. Retrait impossible d'un cathéter de péridural. Ann Fr Anesth Réanim. 27 : 1016-1018.
12. Gehan G, De Mongolfier R, Coulon J-M, Mahanna B and Bahloul H. 2010. Rupture d'un cathéter péridural, devenir de l'extrémité laissée en place. À propos d'un cas. Ann Fr Anesth Réanim. 29 : 403-404.
13. Ates Y, Yücesoy CA, Ünlü AM, Saygin B and Akkas N. 2000. The mechanical properties of intact and traumatized epidural catheters. Anesth Analg. 90 : 393- 399.
14. Gonzalez Fiol A, Horvath R, Schoenberg C, Ahmed N, Dhar SK and Le V. 2016. Comparison of Changes in Tensile Strength in Three Different Flexible Epidural Catheters Under Various Conditions. Anesth Analg. 123 : 233-237.
15. Tsui BCH and Finucane B. 2003. Tensile strength of 19- and 20-gauge arrow epidural catheters. Anesth Analg. 97 : 1524-1526.
16. Browne RA and Politi VL. 1979. Knotting of an epidural catheter: a case report. Can Anaesth Soc J. 26 : 142-144.
17. Blass NH, Roberts RB and Wiley JK 1981. The Case of the Errant Epidural Catheter. Obstet Anesth Dig. 1 : 119.
18. Riegler R and Pernetzky A. 1983. [Unremovable epidural

catheter due to a sling and a knot. A rare complication of epidural anesthesia in obstetrics]. Reg-Anaesthesie. 6 : 19-21.
19. Saderski LR, Schwartz JI, Greenhouse BB, Kennedy TM and Ullman DA. 1988. A Unique Complication of a Lumbar Epidural Catheter. Anesthesiol J Am Soc Anesthesiol. 69 : 634-634.
20. Striebel HW and Dopjans D. 1991. [Knotting of a peridural catheter]. Reg-Anaesthesie. 14 : 104-105.
21. Gozal D and Beilin B. 1996. Removal of Knotted Epidural Catheters. Reg Anesth Pain Med. 21 : 71.
22. Renehan EM, Peterson RA, Penning JP, Rosaeg OP and Chow D. 2000. Visualization of a looped and knotted epidural catheter with a guidewire. Can J Anesth Can Anesth. 47 : 329-333.
23. Hsin S-T, Chang F-C, Tsou M-Y, Liao W-W, Lee T-Y and Lui P-W et al. 2001. Inadvertent knotting of a thoracic epidural catheter: Double-knotted epidural catheter. Acta Anaesthesiol Scand. 45 : 255-257.
24. Damhieu P, Rodriguez V, Decazes Y and Quinio B. 2002. Computed tomography images of entrapped epidural catheter. Reg Anesth Pain Med. 27 : 517-519.
25. Karraz MA. 2002. Knotting of an Epidural Catheter Like a Tie: Anesth Analg. 95 : 257.
26. Gabopoulou Z, Mavrommati P, Chatzieleftheriou A, Vrettou V, Konstandinidou M and Velmachou K. 2005. Epidural Catheter Entrapment Caused by a Double Knot After Combined Spinal-Epidural Anesthesia. Reg Anesth Pain Med. 30 : 588-589.
27. Elsharydah A, Cork RC and Harrel J. 2006. Another knotted epidural catheter. J Clin Anesth. 18 : 554.
28. Arnaoutoglou HM, Tzimas PG and Papadopoulos GS. 2007. Knotting of an epidural catheter : a rare complication : 3.
29. Al-Kayed O, Al-Bouti and Ababneh MO. 2008. Surgical removal of a looped and knotted epidural catheter in a postpartum patient – a case report. Middle East J Anaesthesiol. 19 : 913-918.
30. García-Saura PL, Castilla-Peinado G and Parras-Maldonado MT. 2008. Formación de un nudo verdadero en extremo distal de un catéter, tras su inserción para analgesia epidural obstétrica. Rev Esp Anestesiol Reanim. 55 : 256-257.
31. Esqueda-Arriaga MA. Extracción quirúrgica de catéter peridural retenido. Reporte de un caso. 3 : 5.
32. Huang J, Lawrence J and Sposato M. 2010. Another Case of Knotting of an Epidural Catheter. AANA J. 78 : 93-94.
33. Lala P, Rai A, Langar V and Singh R. 2011. A rare complication of epidural anaesthesia a case report with brief review of literature. Indian J Anaesth. 55 : 629.
34. Singh V, Bhakta P and Ahuja A. 2015. Epidural catheter knot immediately after catheter insertion. Anaesth Intensive Care. 43 : 280-281.
35. Yallapragada SV, Vemuri NN and Shaik MS. 2015. A knotty affair. South Afr J Anaesth Analg. 21 :49-50.
36. Baer LE, Borglund-Hemph A and Jakobsson J. 2017. Epiduralkateter med knut är en ovanlig komplikation – Alltför lång inmatning ökar risken – 4-5 cm rekommenderas. Lakartidningen [Internet]. Available from: http://europepmc.org/abstract/med/29064530
37. Molina García RA, Muñoz Martínez AC, Hoyos Pescador R and de La Torre Espinosa R. 2017. Catéter epidural anudado. Complicación poco frecuente. Reporte de 2 casos. Rev Colomb Anestesiol. 45 : 4-7.
38. Park JT, Cho DW and Lee YB. 2017. Knotting of a Cervical Epidural Catheter in the Patient with Post-Herpetic Neuralgia: A Rare Complication. J Lifestyle Med. 7 : 41-44.
39. Ravindran RS and Karuparthy VR. 1999. An Entrapped Epidural Catheter in a Postpartum Patient. Reg Anesth Pain Med [Internet] 24(5). Available from: http://journals.lww.com/rapm/Fulltext/1999/24050/An_Entrapped_Epidural_Cath eter_in_a_Postpartum.24.aspx
40. Jongleux EF, Miller R and Freeman A. 1998. An Entrapped Epidural Catheter in a Postpartum Patient. Reg Anesth Pain Med [Internet], 23(6). Available from: http://journals.lww.com/rapm/Fulltext/1998/23060/An_Entrapped_Epidural_Catheter_in_a_Postpartum.18.aspx
41. Morris GN, Warren BB, Hanson EW, Mazzeo FJ and DiBenedetto DJ. 1996. Influence of patient position on withdrawal forces during removal of lumbar extradural catheters. Br J Anaesth. 77 : 419-420. 01
42. Gozal D, Gozal Y and Beilin B. 1996. Removal of knotted epidural catheters. Reg Anesth. 21 : 71-73.