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Risk Factors and Possible Mechanisms of Intravenous Port Catheter Migration

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WHAT THIS PAPER ADDS

- In a multivariate logistic regression analysis, shallow tip location (relative to the carina) and the presence of lung cancer were statistically significantly associated with catheter-tip migration.
- Results recommend that shallow tip location should be avoid during implantation and that closer surveillance should be undertaken among patients with lung cancer.

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ABSTRACT

Objective: To identify the risk factors for catheter migration and demonstrate possible mechanisms of this migration.
Design: Retrospective study.
Setting: Chang Gung Memorial Hospital, a tertiary medical centre in Taiwan.
Patients: Patients who underwent implantation of intravenous ports via the superior vena cava (SVC).
Interventions: Procedures involving catheter placement and re-intervention for catheter migration.
Main outcome measures: The anatomic location of the catheter tip was confirmed by plain chest X-rays (postero-anterior view). From these plain radiographs, the distance (in cm) between the carina and catheter tip and the angle (in degrees) between the locking nut and catheter were measured.
Methods: A total of 1542 procedures related to intravenous port implantation were retrospectively reviewed but only procedures involving implantation via the SVC were included in the analysis. The study group was composed of 31 interventions because of catheter migration, while the control group consisted of 1475 implantation and re-intervention procedures except those involving catheter migrations.
Results: Shallow catheter-tip location ($p < 0.0001$) and the presence of lung cancer ($p = 0.006$) were risk factors for catheter migration.
Conclusions: Shallow catheter-tip location and the presence of lung cancer are risk factors for catheter migration. Strategies that ensure low catheter-tip location and avoid increased thoracic pressure may be useful preventive measures.

Reliable venous access is crucial in the treatment of patients who require chemotherapy, prolonged antibiotic therapy, total parenteral nutrition and frequent blood sampling. Although tunnelled catheters can provide venous access, intravenous ports allow more patient activity, require no external dressing and show fewer infectious complications.[1] However, with increasing use of intravenous ports, complications are being encountered in some cases. The complication rate reportedly ranges from 0.4% to 29%.[2]

Catheter migration is often observed in patients who undergo intravenous port implantation. It may result not only in local phlebitis but also in venous thrombosis.[3] Literature review shows that catheter migration is caused by several factors, including physical movement, positive pressure ventilation, the 'jet effect' from catheter irrigation and decreased blood flow associated with venous dilation in patients with congestive heart failure.[2] However, the risk factors and possible mechanisms have not been analysed. The present study aimed to identify risk factors for catheter migration and demonstrate the possible mechanisms using imaging evidence.

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Materials and Methods

Ethical approval for research

The ethical approval for research was approved by the institutional review board (IRB) of Chang Gung Memorial Foundation (CGMF) on 17 June 2010. The IRB is organised and operates according to Good Clinical Practice and the applicable laws and regulations. The informed consent form vision was 99-1558B-0604. The CGMF IRB no. is 99-1558B.

Patient selection

A total of 1542 procedures related to intravenous port implantation were performed at Chang Gung Memorial Hospital between 1 January 2006 and 31 December 2006. The patients were followed up until 30 June 2010. Only patients who received the intravenous ports via the superior vena cava (SVC) were included. Patients who received intravenous port implantation in other hospitals or those who received the intravenous ports via the inferior vena cava were excluded. Catheter migration was identified in 25 patients (21 males and four females) and 31 interventions were performed for catheter adjustment or for port changing.

Further, 1475 procedures, including intravenous port implantation and all re-interventions except those for catheter migration via the SVC, were selected as the control group. The last out-patient follow-up date was considered the end point of follow-up for living patients, whereas the date of death or discharge was the end point of follow-up for mortalities or those discharged in critical condition.

Devices and their use

The intravenous ports used were those that required single-lumen access. Four different types were used, that is, the Arrow Fr. 8 (Arrow International, Inc., PA, USA), Bard Fr. 8 (Bard access system, Inc., Utah, USA), Bard Fr. 6.6 (Bard access system, Inc., Utah, USA) and Tyco Fr. 6 (Tyco healthcare group, Connecticut, USA). Implantation through the SVC route via right-sided approach was preferred because this route required a shorter catheter. The left-sided vessels were used only if no right-sided entry vessel was available. The cephalic vein was the first choice for entry exploration. In the absence of proper cephalic or concomitant veins of the thoraco-acromial artery, the subclavian vein or the internal jugular vein was used as entry vessel.

Implantation method

The vessel cut-down method was used for catheter cannulation. After venostomy, the distal end of the entry vessel was controlled and the catheter was inserted via entry vessel to SVC. A vessel cut-down method was preferred to minimise injury under direct vision. In addition, fluoroscopy was used to confirm the catheter-tip location intra-operatively. For cases showing some difficulty during blunt catheter implantation, a metallic guide-wire was used to establish adequate catheter route prior to implantation. The catheter was slid over the wire to an adequate position under fluoroscopic guidance and the metallic wire was removed after the procedure. If the vessel diameter was too small for catheter insertion, a modified puncture technique described by Coit and Turnbull was used.[4]

Follow-up and surveillance

A percutaneous withdrawal test was conducted to verify the functioning of the intravenous port. The anatomic location of the catheter tip was confirmed by plain chest radiography (postero-anterior view). The angle between the locking nut and the proximal end of the catheter was defined as the angle between the locking nut and the catheter (Fig. 1A). The A-line was the midline of the locking nut, whereas the B-line was the tangent to the proximal end of the catheter. The ideal catheter location was at the junction of the SVC and the right atrium (RA), with the location of the carina defined as the 'zero point'. A negative value was recorded if the catheter tip was located below the carina, and a positive value was recorded if the tip was above it (Fig. 1B). Using the plain chest X-rays, the distance (in cm) between the carina and the catheter tip and the angle (in degrees) between the locking nut and the catheter were measured using the measurement function of the Picture Archiving and Communication System (PACS) (GE, Fairfield Connecticut, USA).

Statistical analysis

Univariate analysis was conducted to examine the relationship of potential factors between migration and non-migration group. The ages, angles and tip locations were compared using the *t*-test. Catheter route, gender and port types were compared using the chi-square or Fisher's exact test for categorical variables. For adjustment for potential confounders, multivariate logistic regression models were used to evaluate the impact of related factors between migration and non-migration group. In a stepwise model selection, we included variables where a p-value ≤ 0.15 provided a guideline for a variable to remain in the model. Consequently, descriptive statistics and multiple regression models were performed using Statistical Analysis Software (SAS) statistical package (version 9.1.3, SAS Institute). A p-value of less than 0.05 was considered to indicate statistical significance, and all tests were two tailed.

Results

The characteristics of the patients in the two groups showed that majority of patients in the migration group (84%, 21/25) were male and 67.7% (21/31) of those who underwent re-intervention for catheter migration had lung cancer. In the non-migration group, 56.1% (828/1475) were male and 25.6% had lung cancer. Only 11 patients received the Tyco intravenous port implantation because it was available only in late 2006. The mean age of patients in the migration and non-migration groups was 60.26 and 59.96 years, respectively, while the mean distance between the tip and the carina was 0.04 and 2.98 cm below the carina, respectively. The mean angle between the locking nut and the catheter in the two groups was 154.08° and 150.83°, respectively (Table 1).

In the present study, the intervention-free period of the migration and non-migration group was 132.94 (range, 1–1069 days) and 415.96 days (range, 0–1996 days), respectively. The mean operation time in the migration and non-migration groups was 41.81 and 38 min, respectively. All of the patients with migrated catheter were symptom free and were all identified by regular routine plain chest X-rays on follow-up. All of the patients received catheter adjustments to the junction between the SVC and RA under fluoroscopic guidance to avoid possible fatal complications. In both groups, the cephalic vein was the predominant entry vessel (Table 2). None of the patients in the migration group received intravenous port implantation via the internal jugular vein. By contrast, all possible entry vessels were used for catheter cannulation in the non-migration group.

The relationship between underlying disease and catheter migration was analysed. Based on a comparison of characteristics between the two groups, only male gender, shallow tip location and the presence of lung cancer were identified as risk factors for

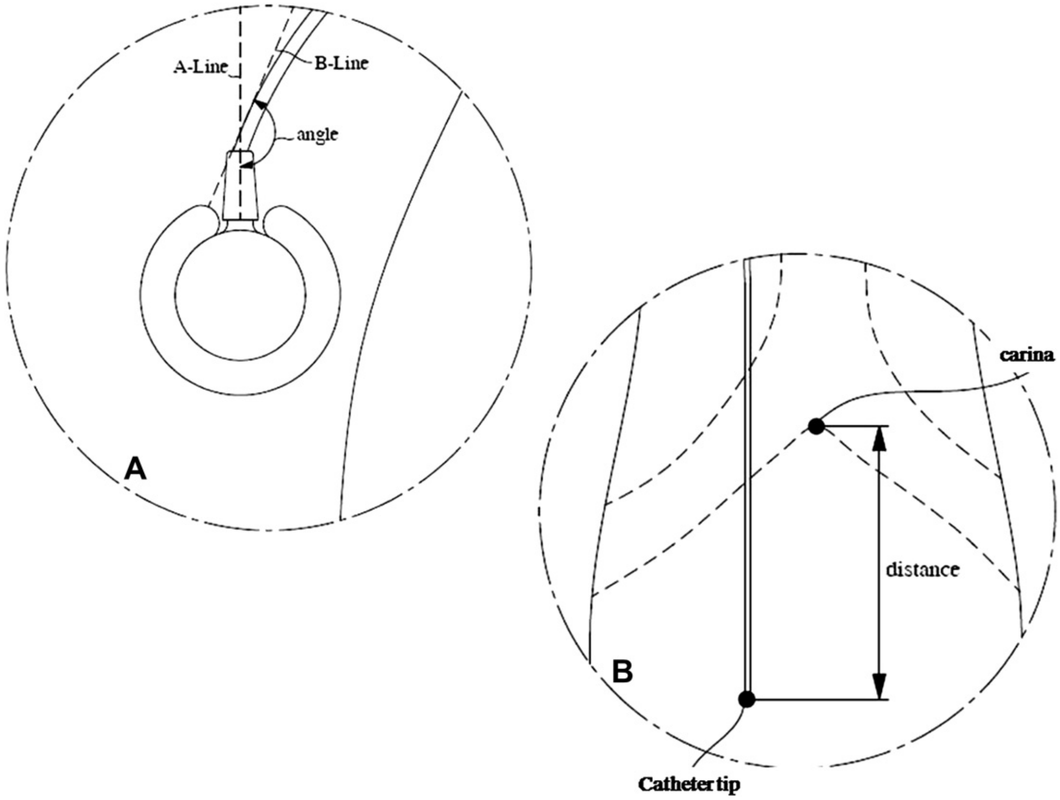

Figure 1. (A) Definition of the angle between the locking nut and catheter (angle). (B) Definition of the catheter-tip location (location).

Table 1
Comparison of the characteristics of the migration and non-migration groups.

	Migration group	Non-migration group	p-value
Procedure No.	31	1475	
Age	60.26 ± 9.04	56.96 ± 13.47	0.06
Mean	60.26	56.96	
Range	40–80	8–94	
Gender			<0.001
Male	4	647	
Female	27	828	
Port type			0.54
Open tip port			
Arrow Fr. 8.1	4	420	
Bard Fr. 6.6	15	391	
Tyco Fr. 6	0	11	
Valve tip port			
Bard Fr. 8	12	653	
Distance between tip and carina	0.04 ± 3.49	−2.98 ± 2.36	<0.001
Average	−0.04	−2.98	
Range	−4.75 to 7.588	−10.608 to 3.818	
Angle	154.08 ± 35.01	150.83 ± 27.67	0.61
Average	154.08	150.83	
Range	61–178.7	30.3–180	
Route			0.99
Via internal jugular vein	0	63	
Via non-internal jugular vein	31	1412	
Underlying disease[a]			
Head and neck malignancy	0 (0%)	156 (10.58%)	0.03
Lung malignancy	21 (67.74%)	377 (25.63%)	<0.0001
Mediastinal malignancy	4 (12.90%)	135 (9.15%)	0.52
Abdominal malignancy	4 (12.90%)	426 (28.88%)	0.07
Soft tissue malignancy	2 (6.45%)	206 (13.97%)	0.30
Haematologic malignancy	0 (0%)	160 (10.88%)	0.06
Unknown primary	0 (0%)	5 (0.34%)	1.00
Poor vascular access	0 (0%)	6 (0.41%)	1.00

[a] Four patients with double malignancy were excluded for analysis.

catheter migration (Table 1). Male patients were predominant in the migration group ($p < 0.001$) and the relatively shallow tip location in this group also showed statistical significance ($p < 0.001$). Furthermore, patients with lung cancer had higher migration rates ($p < 0.0001$). However, the patient's age, the angle between the locking nut and catheter, the type of intravenous port and the entry route of the catheter showed no statistical significance with catheter migration. In a multivariate logistic regression analysis involving all of the factors, shallow tip location ($p < 0.0001$) and the presence of lung cancer ($p = 0.006$) were statistically significant and showed in Table 3.

Discussion

Spontaneous migration of a central catheter is not a rare clinical event. Lum and Soski reported 25 spontaneous migrations in 1794

Table 2
Entry vessels.

Entry vessels	Patient	
	Migration group	Non-migration group
Right internal jugular vein	0	48
Right cephalic vein	24	1034
Right thoraco-acromial vessel	0	7
Right subclavian vein	5	189
Right axillary vein	0	1
Right external jugular vein	0	1
Left internal jugular vein	0	15
Left cephalic vein	2	139
Left thoraco-acromial vein	0	0
Left subclavian vein	0	39
Left axillary vein	0	1
Left external jugular vein	0	1

Table 3
Results of the logistic regression analysis.

Variables	β coefficient	Standard error	Chi-square	Odds ratio	95% CI[a]	p-value
Age	−0.01	0.02	0.54	0.99	(0.96,1.02)	0.46
Gender Male vs. female	0.39	0.29	1.86	2.19	(0.71,6.73)	0.17
Port Open tip vs. valved tip	−0.02	0.22	0.01	0.96	(0.41,2.22)	0.92
Cancer Lung cancer vs. Non-lung cancer	−0.17	0.06	7.35	0.85	(0.75,0.95)	0.006
Distance	0.49	0.09	31.81	1.63	(1.37,1.92)	<0.0001
Angle	−0.004	0.01	0.29	0.99	(0.98,1.10)	0.59

[a] CI means confidence interval.

catheters placed over a 5-month period.[5] The reported incidence of catheter migration varies from 1.3% to 5.4%,[6] and it is undesirable because of the potentially catastrophic results of injecting chemotherapeutic drugs or hypertonic fluid into small-calibre veins. Literature review shows that continuous infusion into small venous vessels via migrated central venous catheter may result in local phlebitis,[3] venous thrombosis,[3] chest or back pain,[7] cardiac tamponade[8] and even brachial plexopathy.[9] In addition, retrograde infusion of agents into the internal jugular vein has been reported to cause numerous complications like neck, shoulder and ear pain, as well as ear gurgling (sound of running stream rushing past the ear), neurologic deficits and cortical vein thrombosis.[10–12]

Literature review shows that catheter migration may be caused by positive pressure ventilation or decreased blood flow associated with venous dilation in patients with congestive heart failure.[2] However, patients with cardiac failure or positive pressure ventilation were considered poor performance status who were excluded for port implantation. Therefore, we have no clinical data for these patients. Intra-operative angiography was performed during the adjustment of the migrated catheter in a lung cancer patient with severe cough (Fig. 2). After repeated catheter migration, he underwent catheter revision. While the patient coughed, intra-thoracic pressure increased and worked on the horizontal portion of the catheter. The catheter migrated upward (Fig. 2A, black arrow) and returned to its original position after the coughing ceased (Fig. 2B). After successive episodes of cough, the persistently increased thoracic pressure caused the catheter to migrate upward and form a loop around the right internal jugular vein (Fig. 2C and D, black arrow). The schematic effects of increased intra-thoracic pressure on the catheter were shown in Fig. 3.

Migration of the catheter tip is believed to be a function of physical forces acting on the catheter.[2] The possible mechanisms that lead catheter migration are as follows. First, when the intra-thoracic pressure increases, it exerts pressure on the horizontal portion of the catheter. The actual force is the product of the pressure and the area of the transverse portion of the catheter. The horizontal force division causes a medial migration of the catheter tip while the vertical force division causes its upward migration. These effects cause the catheter tip to move upward from the junction of the SVC and RA to the upper part of the SVC. This, in turn, leads to flattening of the curvature of the catheter and increases the length of the catheter exposed to the upward forces caused by increased intra-thoracic pressure. This portion of the catheter is more likely to move upward and deviate to the right internal jugular vein because of the relatively straight vascular route.

In the present study, migrations to the internal jugular vein accounts for more than half (51.6%) of the cases of catheter migration. If such physical events continue, the catheter will be further pushed to the internal jugular vein, thereby leading to permanent catheter migration. If less force is generated, blood flow from the SVC may return downward to the RA and may carry the pliable catheter to other venous distributions like the pericardiophrenic and internal mammary veins, thereby causing

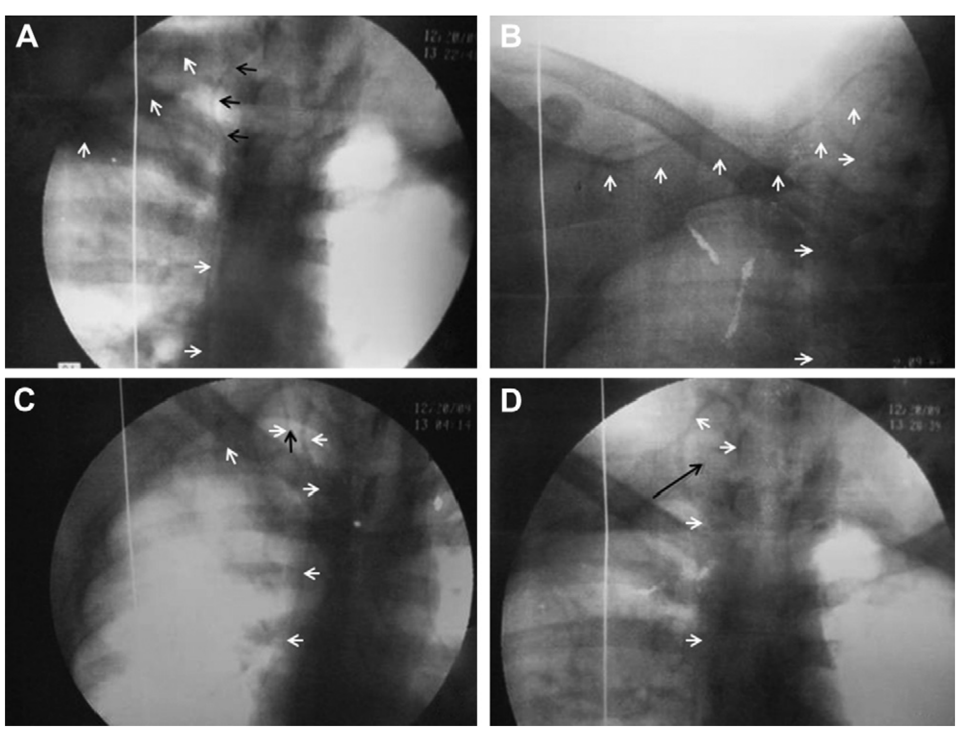

Figure 2. Results of intra-operative angiography.

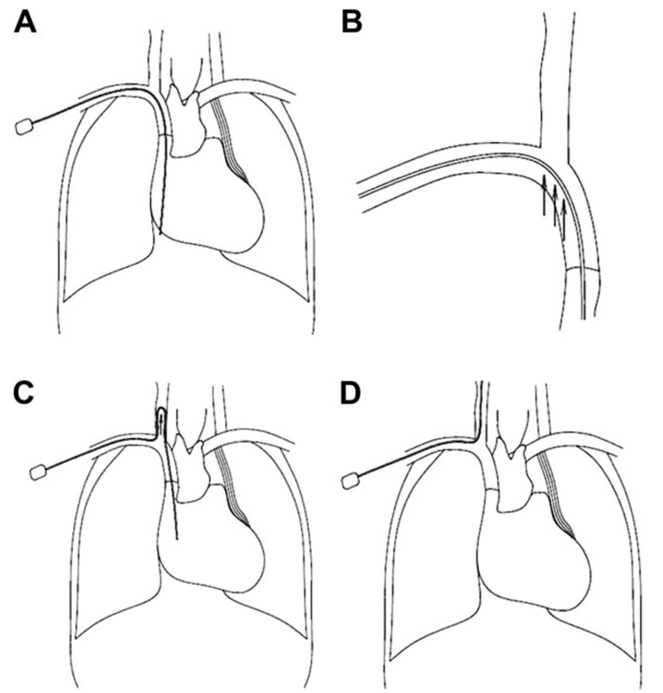

Figure 3. Schematics of the effects of increased intra-thoracic pressure on the catheter. (A) Catheter status prior to intra-thoracic pressure increase (B) Black arrows show how the increased intra-thoracic pressure worked on intravenous catheter (C) Catheter migrated and formed a loop in internal jugular vein because of increased intra-thoracic pressure (D) Catheter migrated to internal jugular vein under persistent increased intra-thoracic pressure.

chest and back pain or even cardiac tamponade.[6,7] All strategies that avoid increased thoracic pressure may be useful in preventing catheter migration.

The correct position of the central venous catheter tip is still under debate.[13] Some authors favour the right atrial–SVC junction as the optimal position, but many interventionists prefer a tip position within the RA. The junction between the SVC and RA is invisible on plain chest X-rays but is generally accepted to be below the carina. Aslamy et al. found that the right trachea-bronchial angle (TBA) is consistently at least 2.9 cm cephalad to the junction of the RA.[14] This means that the junction between the SVC and RA is around 1–2 cm below the carina.

Another critical factor is the catheter tip movement after placement.[15] Significant upward movement of the tip is often noted on chest X-rays. The catheter shows an average peripheral migration of 20 mm in posture change from supine to standing position. Therefore, to ensure that the catheter tip is positioned in the upper RA or the SVC–RA junction, it has to be placed well into the RA in the supine position.[15] Placing the catheter 1–2 cm in the atrium and checking for a flickering visualisation of the catheter on fluoroscopic imaging usually ensures correct placement.[16]

In this retrospective study, the catheter tip was located 2.98 cm below the carina in the non-migration group and only 0.04 cm below the carina in the migration group. This showed adequate catheter tip placement in the non-migration group and high tip location in the migration group. From multivariate analysis, there is an increased risk of catheter migration if the catheter is short or if chest plain radiographs show a high tip location ($p < 0.0001$). In addition, patients with lung cancer have higher risk of catheter migration than non-lung cancer patients ($p = 0.006$). This may be caused by cough or mediastinal lymphadenopathy related to lung cancer. However, further investigation and prospective studies are warranted to further clarify the relationship.

Male patients show higher risk of catheter migration by chi-square test ($p = 0.006$). However, by multivariate logistic regression analysis, there is no relationship between gender and catheter migration ($p = 0.17$). The gender-related difference in the results may be due to the deep tip location among female patients in both groups. A deeper location is associated with lower risk of catheter migration. Thus, tip location may be the only risk factor for catheter migration. This study also analysed the impact of the entry routes. In the control group, 63 patients received intravenous port implantation via the internal jugular vein and none of them had catheter migration. However, this still needs further study to clarify whether less migration would be encountered via the internal jugular vein route.

The current study has some limitations. First, obesity and overweight are worldwide problems but this study does not have body mass index (BMI) data that can demonstrate the relationships between migration and obesity. Second, patients included in this study were those with malignancy, and shorter overall survival period was expected. The majority of patients died of rapid disease progression or loss of follow up due to transfer for hospice care or completion of chemotherapy. Thus, the actual migration rate may be underestimated. Lastly, this study provides imaging evidence of coughing increases intra-thoracic pressure and leads to catheter migration. However, imaging does not represent the actual mechanisms that cause catheter migration in every case.

Conclusions

The carina is an excellent landmark that indicates the depth of catheter placement. Intra-operative fluoroscopy can confirm the catheter-tip location to avoid technical errors. Proper placement of the catheter tip to the SVC–RA junction is crucial in preventing catheter migration. The possible mechanisms of catheter migration are directly related to the intra-thoracic pressure, and can be demonstrated by intra-operative angiography. High catheter-tip location and the presence of lung cancer are risk factors for catheter migration. Thus, all strategies that ensure a low catheter-tip location and avoid increased thoracic pressure may be useful in preventing catheter migration.

Conflict of Interest/Funding

None.

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