

## Infection Rate of Hickman Catheters Versus Peripherally Inserted Central Venous Catheters in Oncology Patients

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### ABSTRACT

**Objective:** To compare the incidence of catheter-related infection in the bloodstream and non-infectious complication rate of Hickman catheter and peripherally inserted central venous catheter (PICC) in oncology patients.

**Methods:** A retrospective study was performed of oncology patients who underwent Hickman catheter or PICC placement at the radiology department of a regional hospital in Hong Kong from January 2008 to December 2013. The catheter-related bloodstream infection rate, time to infection onset, and non-infectious complication rate of the Hickman group and PICC group were evaluated and compared.

**Results:** During the study period, 161 Hickman catheters and 29 PICCs were inserted in oncology patients ( $n = 190$ ). There were 38 cases of catheter-related bloodstream infection in the Hickman group and four cases in the PICC group. The catheter-related bloodstream infection rate for all catheters, Hickman group, and PICC group was 1.364, 1.340 and 1.654 per 1000-catheter-days, respectively. For non-infectious complications, 15 of 161 Hickman cases had complications (6 catheter blockage, 5 leakage, 4 migration and dislodgement). In the PICC group, 6 of 29 had complications (3 blockage, and 3 migration and dislodgement). There was, however, no statistically significant difference between the Hickman and PICC groups in terms of number of infections ( $p = 0.241$ ), time to infection onset ( $p = 0.187$ ), non-infectious complication rate ( $p = 0.101$ ), and overall complication rate ( $p = 0.766$ ).

**Conclusion:** With the less invasive nature of PICC insertion, it provides a viable means of vascular access for oncology patients.

**Key Words:** Catheterization; Catheters, indwelling; Central venous catheters; Infection

### 中文摘要

#### 癌症患者Hickman導管置入和外周中央靜脈導管置入感染率比較

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**目的：**為癌症患者置入Hickman導管和外周置入中央靜脈導管（PICC），比較兩種方法的導管關聯的血液感染率和非感染性併發症的發生率。

**方法：**回顧研究2008年1月至2013年12月期間於香港一所分區醫院放射科接受Hickman導管或PICC置入的癌症患者。評估及比較兩組患者以下各項指標差異：導管相關性血液感染率、導管置入至感染發生的時間，以及非感染性併發症的發生率。

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Submitted: 9 Dec 2014; Accepted: 9 Apr 2015.

**結果：**研究期間，161名癌症患者接受Hickman導管置入，另29名患者接受PICC（共190例）。導管相關性血液感染病例，Hickman導管組有38例，PICC組4例；導管相關性血液感染率方面，導管留置1000天則整體感染率為1.364，Hickman導管組為1.340，PICC組則為1.654。至於非感染性併發症，Hickman導管組161名患者中有15例（導管堵塞6例、泄漏5例、移動及變位4例），PICC組29名患者中則有6例（堵塞3例、移動及變位3例）。兩組之間在以下幾方面均無統計學上的顯著差異：感染病例數目（ $p=0.241$ ），導管置入至感染發生的時間（ $p=0.187$ ），非感染性併發症發生率（ $p=0.101$ ），併發症總體發生率（ $p=0.766$ ）。

**結論：**微創性PICC置入是癌症患者一種建立血管通路的可行方法。

## INTRODUCTION

Vascular access is always a challenge for oncology patients who require frequent blood sampling and administration of antineoplastic agents, antibiotics, intravenous fluids, nutritional support, and blood products.<sup>1,2</sup> Nonetheless, the upper extremity veins are rapidly exhausted by repeated venipuncture as well as administration of irritating antibiotics and chemotherapy. An indwelling central venous catheter (CVC) facilitates the supportive care of oncology patients,<sup>1,2</sup> but also carries different risks and complications.<sup>3,4</sup>

Several types of indwelling CVCs are commonly inserted in oncology patients, namely (a) tunnelled CVC, including Hickman catheter,<sup>5-9</sup> (b) peripherally inserted central venous catheter (PICC),<sup>10</sup> (c) temporary non-tunnelled CVC,<sup>9</sup> and (d) subcutaneous totally implantable intravascular devices, e.g. Port-A-Cath (Smiths Industries Medical Systems, Deltec, Inc., St. Paul [MN], USA), MediPort (Norfolk, Medina [NY], USA).<sup>11,12</sup> Our study focused on the Hickman catheter and PICC that are more widely used in our hospital.

Both the Hickman catheter and PICC provide effective vascular access, but are associated with risks and complications. The most common complication is infection. From a large review article in 2005 of 200 prospective studies over 40 years,<sup>4</sup> the catheter-related bloodstream infection (CRBSI) rate per 1000-catheter-days of cuffed and tunnelled CVC was 1.6 and that for PICC was 1.1 (2.1 for inpatient and 1.1 for both inpatient and outpatient). In addition to infection, other non-infectious complications occur.<sup>2,13</sup> During percutaneous catheterisation there may be arterial puncture, haematoma, pneumothorax and haemothorax, as well as mechanical problems that can cause catheter malfunction, including migration, thrombosis, embolisation, cuff erosion, and leakage.

Reports about CRBSI rates of Hickman catheters and PICCs revealed diverse results.<sup>4,14-21</sup> The 2011 Guidelines for the Prevention of Intravascular Catheter-Related Infections by Centers for Disease Control and Prevention, USA,<sup>22</sup> offered no recommendation on the selection of Hickman catheter or PICC but suggested that it should be based on the intended purpose and duration of use, known infectious and non-infectious complications, and experience of individual catheter operators.

There is currently no standard protocol in our hospital with regard to selection of catheter in oncology patients. The objective of our study was thus to compare the incidence of CRBSI and non-infectious complication rate for both Hickman catheter and PICC in oncology patients.

## METHODS

During the period January 2008 to December 2013, oncology patients who underwent Hickman catheter or PICC placement at the radiology department of a regional hospital in Hong Kong were retrospectively reviewed.

The Hickman catheter used was Hickman® 9.0 French Dual Lumen Catheter and the PICC was PowerPICC® 5.0 French Single Lumen Catheter. Both models were obtained from Bard Access Systems. An aseptic and Seldinger technique was used for insertion under ultrasound guidance, using the Philips iU22 xMATRIX Ultrasound System together with Probe L12-5 50 mm Linear Array. The catheter tip was placed in the lower part of the superior vena cava, and its position confirmed with fluoroscopy.

All oncology patients followed the standard post-Hickman catheter and PICC care guidelines prepared

by the Department of Clinical Oncology of our hospital. The advice of the guideline includes Hibiscrub handwashing pre- and post-CVC care, regular dressing on designated dates, application of a transparent dressing, catheter-flushing with 0.9% normal saline and heparinised saline (50 units in 5-ml normal saline), regular inspection of the CVC site, and regular review of the ongoing need for the CVC.

Hospital records, radiological and microbiological reports, and medical notes from electronic Patient Record were gathered and analysed. Other data collected included the following: patient gender, age, type of malignancy, type of catheter, site of catheter insertion, indication and date of catheter insertion and removal, the presence of CRBSI, the presence of non-infectious complication(s), and the presence of catheter tip culture and peripheral blood culture.

CRBSI was defined as (i) positive catheter tip culture, (ii) positive blood culture from the catheter, or (iii) septicaemia that resolved only after catheter removal.<sup>13</sup> Total catheter days was defined as the time interval between catheter insertion and catheter removal. The time to infection onset was defined as the interval between catheter insertion and the date when the CRBSI criteria were fulfilled. CRBSI rate per 1000-catheter-days was defined as total number of infections divided by the total catheter days times 1000.

Statistical analysis was performed using the Statistical Package for the Social Sciences (Windows version 22.0; SPSS Inc, Chicago [IL], USA). Statistics Version

22 (Windows 64-bit). The number of CRBSI cases, non-infectious complication rate (including blockage, dislodgement, and leakage), and overall complication rate for the Hickman and PICC groups were compared using Pearson's Chi-square test and Fisher's exact test with two-sided tests (when >20% of expected counts were inadequate or zeroed).

For the mean catheter days and time to infection onset, non-parametric comparison by Mann-Whitney *U* test was performed. A *p* value of <0.05 was taken as statistical significance.

## RESULTS

### Descriptive Results

From January 2008 to December 2013, there were 498 cases of Hickman catheter and PICC insertion, of whom 190 cases were oncology patients and were analysed. Patients' age ranged from 9 to 92 years (mean 47.0, median 49.0 years). Demographic data of both groups are summarised in Table 1. Of the 190 cases, 161 were Hickman catheters and 29 were PICC. Reasons for catheter insertion were chemotherapy (*n* = 163), total parenteral nutrition (*n* = 18), and vascular access (*n* = 9).

For number of catheter insertions per patient, 124 patients in the Hickman group had one catheter insertion only, and 11 patients had multiple catheter insertions. In the PICC group, three patients had multiple catheter insertions. In addition, there were seven patients with multiple catheter insertions with a combination of Hickman and PICC catheters (Table 2).

**Table 1.** Demographic data of Hickman catheter and PICC groups.

Demographics	Hickman catheter (n = 161)	PICC (n = 29)	Total (n = 190)
Gender			
Male	68 (35.8%)	18 (9.5%)	86 (45.3%)
Female	93 (48.9%)	11 (5.8%)	104 (54.7%)
Age (years)			
Mean	45.7	52.3	47.0
Range	9-92	19-86	9-92
Median	49.0	56.0	49.0
Standard deviation	15.8	15.9	15.9
Diagnosis			
Haematological malignancy	104	6	110
Non-haematological malignancy	57	23	80
Indication			
Chemotherapy	142 (88.2%)	21 (72.4%)	163 (85.8%)
TPN	13 (8.1%)	5 (17.2%)	18 (9.5%)
Vascular access	6 (3.7%)	3 (10.3%)	9 (4.7%)

Abbreviations: PICC = peripherally inserted central venous catheter; TPN = total parenteral nutrition.

**Table 2.** Number of catheter insertions per patient.

	Hickman catheter	PICC	Combination of Hickman catheters and PICC	Total
No. of catheter insertions per patient				
1	124	14	0	138
2	8	1	5	14
3	2	2	0	4
4	1	0	2	3
No. of patients	135	17	7	159
No. of catheters	150	22	18	190

Abbreviation: PICC = peripherally inserted central venous catheter.

Type of malignancy was also analysed: 110 cases were haematological (71 leukaemia, 29 lymphoma) and 80 were non-haematological (most were upper and lower gastrointestinal, breast, lung, and head and neck malignancies) [Table 3].

For site of insertion, among the 161 Hickman catheters, most were inserted into the right jugular vein ( $n = 134$ ). In the 29 PICC group, most were inserted into the right basilic vein ( $n = 17$ ) or right cephalic vein ( $n = 5$ ) [Table 4].

### Analytical Results

The total catheter days of the Hickman and PICC groups was 28,365 days and 2419 days, respectively. The mean catheter days was 176 days (range, 0-869 days) for the Hickman group and 83 days (range, 3-419 days) for the PICC group ( $p < 0.001$ ) [Table 5].

Overall, 38 of 161 cases in the Hickman group and 4 of 29 cases in the PICC group had CRBSI ( $p = 0.241$ ). The time to infection onset was 149.9 days for the Hickman group and 55.3 days for the PICC group ( $p = 0.187$ ). The CRBSI rate per 1000-catheter-days was 1.340 for the Hickman group, 1.654 for the PICC group, and 1.364 for overall. For non-infectious complications, 15 Hickman patients and six PICC patients had complications. Details are shown in Table 5.

There was no statistically significant difference between the two groups in terms of number of CRBSIs ( $p = 0.241$ ), time to infection onset ( $p = 0.187$ ), non-infectious complication rate ( $p = 0.101$ ), and overall complication rate ( $p = 0.766$ ).

Subgroup analysis was performed in the 110 haematological and 80 non-haematological cases.

For the haematological group, there were 30 cases of CRBSI in the Hickman group but none in the six PICC cases. There was no statistically significant difference in terms of number of CRBSIs ( $p = 0.186$ ), non-infectious complication rate ( $p = 0.072$ ), and overall complication rate ( $p = 1.000$ ) [Table 6]. In the non-haematological group, the CRBSI rate per 1000-catheter-days in the PICC group was higher than that in the Hickman group, but there was no statistical significant difference in

**Table 3.** Type of malignancy.

Type of malignancy	No. of cases
Haematological	( $n = 110$ )
Leukaemia	71
Lymphoma	29
Multiple myeloma	8
Others	2
Non-haematological	( $n = 80$ )
Gastrointestinal (upper)	10
Gastrointestinal (lower)	12
Breast	15
Lung	12
Nasopharyngeal carcinoma / head and neck	11
Urological / gynaecological	9
Others	11

**Table 4.** Site of catheter insertion.

Site of catheter insertion	No. of cases
Hickman	( $n = 161$ )
Right jugular vein	134
Left jugular vein	23
Right subclavian vein	4
Peripherally inserted central venous catheter	( $n = 29$ )
Right cephalic vein	5
Right basilic vein	17
Left basilic vein	3
Left median cubital vein	1
Right brachial vein	3

terms of number of CRBSIs ( $p = 0.736$ ), mean time to infection onset ( $p = 0.752$ ), non-infectious complication rate ( $p = 0.271$ ), or overall complication rate ( $p = 0.271$ ) [Table 7].

Of the 190 catheters, number of catheter days ranged from 0-869 days (Figure); 13 cases (8 Hickman catheters, 5 PICC) had catheter days of  $\leq 10$ , while 35 cases (23 Hickman catheters, 12 PICC) had catheter days of  $\leq 30$ . We performed further analysis of the subgroups with catheter days of  $>10$  and  $>30$ . There

was no statistically significant difference between the Hickman catheter and PICC groups in terms of number of CRBSI cases, mean time to infection onset, non-infectious complication rate, or overall complication rate (Table 8).

## DISCUSSION

The Hickman catheter is a silicon catheter that serves as a tunnelled CVC. It was proposed by Hickman et al<sup>6</sup> in 1979 for venous access in bone marrow transplant patients and was modified from the Broviac catheter

**Table 5.** Catheter days and complication rates.

	Hickman (n = 161)	PICC (n = 29)	Total (n = 190)	p Value
Total catheter days	28,365	2,419	30,784	-
Mean (range) catheter days	176 (0-869)	83 (3-419)	162 (0-869)	<0.001
CRBSI				
No. of infections	38 (23.6%)	4 (13.8%)	42 (22.1%)	0.241
CRBSI rate per 1000-catheter-days	1.340	1.654	1.364	-
Time to infection onset (days)	149.9	55.3	140.9	0.187
Non-infectious complications				
No. of complications	15 (9.3%)	6 (20.7%)	21 (11.1%)	0.101
Blockage	6	3	9	0.142
Dislodgement / migration	4	3	7	0.073
Leakage / perforation	5	0	5	1.000
Total No. of complications	51 (31.7%)	10 (34.5%)	61 (32.1%)	0.766

Abbreviations: CRBSI = catheter-related bloodstream infection; PICC = peripherally inserted central venous catheter.

**Table 6.** Catheter days and CRBSI (haematological malignancy subgroup).

	Hickman (n = 104)	PICC (n = 6)	Total (n = 110)	p Value
Total catheter days	21,921	651	22,572	-
Mean catheter days	210.8	108.5	205.2	0.113
CRBSI				
No. of infections	30 (28.8%)	0	30 (27.3%)	0.186
CRBSI rate per 1000-catheter-days	1.369	0	1.329	-
Time to infection onset (days)	174.0	N/A	174.0	N/A
No. of non-infectious complications	10 (9.6%)	2 (33.3%)	12 (10.9%)	0.072
No. of overall complications	38 (36.5%)	2 (33.3%)	40 (36.4%)	1.000

Abbreviations: CRBSI = catheter-related bloodstream infection; N/A = not applicable; PICC = peripherally inserted central venous catheter.

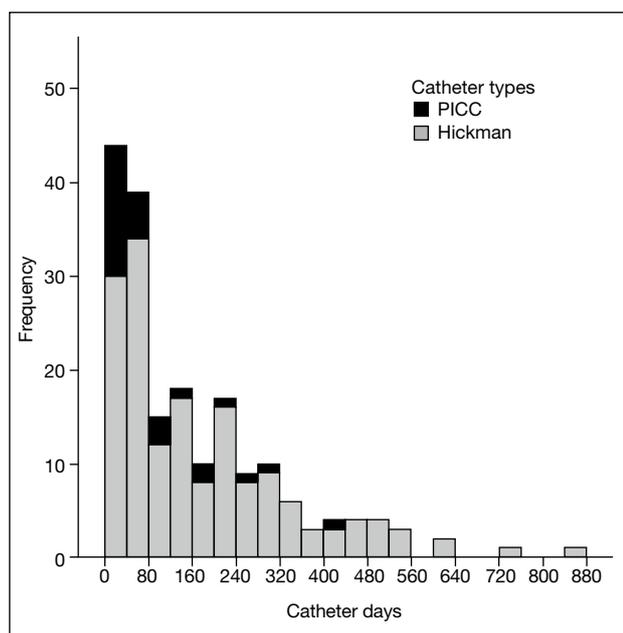
**Table 7.** Catheter days and CRBSI (non-haematological malignancy subgroup).

	Hickman (n = 57)	PICC (n = 23)	Total (n = 80)	p Value
Total catheter days	6444	1768	8212	-
Mean catheter days	113.1	76.9	102.7	0.041
CRBSI				
No. of infections	8 (14.0%)	4 (17.4%)	12 (15.0%)	0.736
CRBSI rate per 1000-catheter-days	1.241	2.262	1.461	-
Time to infection onset (days)	59.3	55.3	57.9	0.752
No. of non-infectious complications	5 (8.8%)	4 (17.4%)	9 (11.3%)	0.271
No. of overall complications	13 (22.8%)	8 (34.8%)	21 (26.3%)	0.271

Abbreviations: CRBSI = catheter-related bloodstream infection; N/A = not applicable; PICC = peripherally inserted central venous catheter.

introduced in 1973. The wider luminal diameter of 1.6 mm in Hickman catheter compared with 1.0 mm of the Broviac catheter allowed easier venous blood sampling and infusion.<sup>6,7</sup> The Dacron cuff serves as a barrier to infection by allowing fibrous ingrowth.

The PICC was first introduced by Hoshal in 1975.<sup>23</sup> It is a silicone-elastomer catheter that is inserted into the basilic or cephalic vein, and was first used for total intravenous nutrition. It gained popularity in the 1990s and is now used for chemotherapy, vascular access, blood product transfusion, venous sampling, and nutritional support.



**Figure 8.** Frequency of catheter days. Mean ± SD : PICC (n = 29), 83.4 ± 100.2; Hickman (n = 161): 176.2 ± 164.0. Abbreviations: PICC = peripherally inserted central venous catheter; SD = standard deviation; TPN = total parenteral nutrition.

Both Hickman catheter and PICC have been in use for more than 40 years, with a diversity in the reports about infection rates.<sup>4,14-21</sup> Some studies have suggested a lower risk of infection in PICC,<sup>14-19</sup> but others disagree.<sup>4,20,21</sup>

In the systematic review by Maki in 2006,<sup>4</sup> PICC in hospitalised patients showed the highest CRBSI rate (2.1 per 1000-catheter-days; 95% confidence interval [CI], 1.0-3.2), followed by cuffed and tunneled CVC (1.6 per 1000-catheter-days; 95% CI, 1.5-1.7), then pooled mean of inpatient and outpatient PICC (1.1 per 1000-catheter-days; 95% CI, 0.9-1.3), and outpatient PICC (1.0 per 1000-catheter-days; 95% CI, 0.8-1.2).

In another prospective cohort study of all adult patients with a CVC in a haematology-oncology unit from January 2004 to March 2007,<sup>14</sup> among the 1127 CVCs (154 Hickman catheters, 807 PICC, 166 non-tunneled catheters or implantable devices) in 727 patients, the hazard ratio of CRBSI for the Hickman catheter was 2.78 times that for PICC (p = 0.0035).

A most recent systematic review and meta-analysis in 2013 by Chopra et al<sup>16</sup> compared the infection rate of PICC and CVC. He included studies that involved patients aged 18 years or above with PICC or CVC insertion, and reported the infection rates. The pooled meta-analyses of the 23 studies (52,175 cases) showed a lower infection risk for PICC than CVC, with a relative risk (RR) of 0.62 when number of infection cases was compared. Of the 13 studies (50,667 cases) that reported infection in catheter-days, the RR of PICC to CVC was 0.92 only (range, 0.41-1.27). When only inpatients were compared, there was no statistically significant difference in risk of infection between PICC and CVC (RR, 0.72; range, 0.41-1.27).

**Table 8.** Catheter days and CRBSI.

	Catheter days >10				Catheter days >30			
	Hickman (n = 153)	PICC (n = 24)	Total (n = 177)	p Value	Hickman (n = 138)	PICC (n = 17)	Total (n = 155)	p Value
Total catheter days	28,322	2392	30,714	-	27,979	2231	30,210	-
Mean catheter days	185.1	99.7	173.5	0.003	202.8	131.2	194.9	0.051
CRBSI								
No. of infections	36 (23.5%)	3 (12.5%)	39 (22.0%)	0.225	33 (23.9%)	3 (17.6%)	36 (23.2%)	0.764
CRBSI rate per 1000-catheter-days	1.271	1.254	1.270	-	1.179	1.345	1.192	-
Time to infection onset (days)	157.9	73.3	151.4	0.196	170.3	73.3	162.2	0.338
No. of non-infectious complications	13 (8.5%)	5 (20.8%)	18 (10.2%)	0.075	11 (8.0%)	4 (23.5%)	15 (9.7%)	0.064
No. of overall complications	47 (30.7%)	8 (33.3%)	55 (31.1%)	0.797	42 (30.4%)	7 (41.2%)	49 (31.6%)	0.369

Abbreviations: CRBSI = catheter-related bloodstream infection; PICC = peripherally inserted central venous catheter.

This difference may be attributed to various factors.<sup>4</sup> First of all, the study population possibly involved a quite heterogeneous group of patients from infants to adults, from intensive care patients to oncology patients or haemodialysis patients. They might also have had a range of immunity status or underlying disease. Second, the catheter might have been inserted for different purposes and durations. Removal of catheter could have been for treatment completion, or due to infection, complication, or patient death. Third, the definition of CRBSI varied in different studies.<sup>2,4,16,22</sup> Routine catheter removal in suspected cases of infection was not suggested,<sup>1,2,22,24,25</sup> making the semi-quantitative and quantitative diagnosis difficult. In addition, it remained undetermined whether CVC change over a guidewire, insertion of a new CVC at a new site, or watchful waiting was preferred among patients with suspected but unconfirmed catheter-related infection, pending blood culture results.<sup>25</sup>

There was no statistically significant difference between Hickman catheter and PICC in terms of CRBSI (number of infection and time to infection onset), non-infectious complications, or overall complications.

The CRBSI rate in our study was comparable with other studies. The CRBSI rate for the Hickman group and PICC group was 1.340 and 1.654 per 1000-catheter-days respectively, comparable with the Maki systematic review<sup>4</sup> that reported 1.6 for Hickman catheter (range, 1.5-1.7) and 2.1 for PICC inpatients (range, 1.0-3.2).

Number of catheter days in our study was diverse, ranging from 0 to 869 days (Figure). Catheter days in the Hickman group were significantly longer than those in the PICC group. This may be because clinicians tend to use Hickman lines in patients who require a longer duration of therapy, reserving PICC for those who require shorter treatment duration. Cases with CVC insertion for more than 1 year were analysed. Of the 22 cases, 21 were Hickman catheters and only one was PICC.

Cases with short duration of catheter use were analysed as outlier cases. We used two cut-offs at 10 days and 30 days arbitrarily. For the 13 cases with CVC inserted for  $\leq 10$  days, eight were Hickman catheters and five were PICC; six were removed as the patient died, one was due to treatment completion, three were due to infection, and three were due to non-infectious complications. When the 30-day mark was used, 35 cases (23 Hickman

catheters and 12 PICC) had the catheter in situ for  $<30$  days; 13 were removed because the patient died, eight were due to treatment completion, one was pulled out by the patient, and 11 were due to complications. A considerable number of catheters were removed shortly after insertion because of patient demise.

The short-catheter-days outliers may affect the statistical comparison between Hickman and PICC groups. Therefore, we also analysed the CRBSI of two groups when the outliers were excluded. When the catheter-days of  $\leq 10$  days as well as  $\leq 30$  days were excluded, the number of CRBSI cases, mean time to infection onset, non-infectious complication rate, and overall complication rate showed no statistically significant difference between Hickman and PICC groups. This was consistent with our overall findings.

Despite the wide range of catheter days, it should be noted that there was no statistically significant difference in time to infection onset in Hickman catheter and PICC. Despite the longer mean catheter days of Hickman catheters, there was no difference in the time infection developed.

There were some limitations in our study. First, this was a non-randomised retrospective study and selection bias existed. In an attempt to have a more focused and homogeneous group of patients, only oncology patients with a CVC were included, not haemodialysis or intensive care patients. We performed subgroup analysis of haematological and non-haematological malignancy. Some clinicians may have preferred a certain catheter, for example Hickman catheter, for longer duration of use and PICC for shorter duration. Thus we also performed subgroup analysis for catheters in place for  $>10$  days and  $>30$  days to eliminate the outlying effect of extra short-duration catheters. Second, although 6 years of data were analysed giving a total of 190 cases, there remained only a relatively small number of PICCs (29 cases, 15.3%) with only four infected. This limited further subgroup analysis. Studies of longer duration or prospective randomised control trials are warranted.

## CONCLUSION

Vascular access is crucial to many oncology patients, but there is currently no consensus on the preferred CVC. In our 6-year study, we compared two widely used CVCs, the Hickman catheter and PICC. There was no statistically significant difference between the two in terms of CRBSI rate, time to infection onset, rate of

infection per catheter day, non-infection complication rate, and overall complication rate. With the less invasive nature of PICC insertion, it offers a viable means of vascular access for oncology patients.

## ACKNOWLEDGEMENTS

No conflicts of interest nor financial subsidy were declared by the authors. The study was approved by New Territories West Cluster (NTWC) Ethics Committee. We would like to acknowledge NTWC Quality & Safety Division Statistical Officer, Mr Jaden Lam, for his suggestion and advice on statistical methodology.

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