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Application of peripherally inserted central catheter in acute myeloid leukaemia patients undergoing induction chemotherapy

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Increasingly, peripherally inserted central catheters (PICC) are applied in patients with haematological malignancies. The feasibility and safety of PICC for induction chemotherapy in acute myeloid leukaemia (AML) remain unclear. Medical records of 89 newly diagnosed adult de novo AML patients, who achieved complete remission, were retrospectively reviewed (PICC group, $n = 43$; intravenous [IV] line group, $n = 46$). Patients' clinical characteristics and the number of blind punctures for blood sampling were compared between these two groups, and risk factors associated with bacteraemia were identified by univariate analysis. Patients in the PICC group experienced significantly fewer blind punctures than those in the IV line group (3.3 ± 3.6 vs. 14.4 ± 6.0; $p = .000$); 20.9% of PICC patients had bacteraemia, compared with 23.9% in the IV line group ($p = .803$). Most patients (76.7%) removed their PICC because treatment was completed. PICC increased the quality of life in AML patients undergoing chemotherapy induction by reducing the number of blind blood punctures required. Bacteraemia in PICC patients was comparable to that in IV line patients. PICC is, therefore, a feasible and safe central venous device for use in AML patients.

KEYWORDS
acute myeloid leukaemia, bacteraemia, chemotherapy, haematological malignancy, intravenous line, peripherally inserted central catheter

1 | INTRODUCTION

Acute myeloid leukaemia (AML) is one of the most common haematological malignancies and originates from myeloid hematopoietic cells. AML is confirmed when more than 20% of nucleated cells found in either bone marrow or peripheral blood are myeloblasts, according to World Health Organization criteria (Vardiman et al., 2009). Abnormal cell proliferation, differentiation or apoptosis underlies the pathogenesis of this disease (Reilly, 2005).

Treatment of AML is complicated. For outcome prediction and treatment strategies, patients with AML are stratified into high-risk, intermediate–high-risk, intermediate–low-risk, and low-risk groups according to cytogenetic abnormalities and molecular mutations (Burnett, Wetzler, & Lowenberg, 2011). Induction chemotherapy, followed by consolidation chemotherapy, is considered to be the standard of care for low-risk AML (Robak & Wierzbowska, 2009). However, allogeneic hematopoietic stem cell transplantation is suggested for intermediate and high-risk AML patients (Burnett et al., 2011). Regardless of risk classification-based treatment, complete haematological remission by induction chemotherapy is the first therapeutic goal, which can be achieved in around 70% of newly diagnosed AML patients (Lynch & Medeiros, 2015).

TABLE 1 Clinical characteristic comparison between patients in PICC and IV groups

	All patient (n = 89)	PICC group (n = 43)	IV group (n = 46)	p
Age (years)	47.8 ± 14.4	46.7 ± 14.4	48.9 ± 14.5	.648[a]
Gender (n, %)				
M	45 (51.0)	22 (51.0)	23 (50.0)	1.000[b]
F	44 (49.0)	21 (49.0)	23 (50.0)	
Leucocyte (no./μl)	48,276.5 ± 60461.9	47,484.7 ± 54922.9	49,016.7 ± 65819.6	.786[a]
Haemoglobin (g/dl)	8.1 ± 2.1	8.0 ± 1.9	8.1 ± 2.3	.718[a]
Platelet (no./μl)	74,098.9 ± 73751.7	70,139.5 ± 70139.5	77,800.0 ± 77696.2	.825[a]
Subtypes (n, %)				
M1	7 (7.9)	4 (9.3)	3 (6.5)	.331[b]
M2	57 (64)	26 (60.5)	31 (67.4)	
M4	19 (21.3)	12 (27.9)	7 (15.2)	
M5	5 (5.6)	1 (2.3)	4 (8.7)	
M6	0 (0)	0 (0)	0 (0)	
M7	1 (1.1)	0 (0)	1 (2.2)	
Regimens (n, %)				
I3A7	80 (89.9)	39 (90.7)	41 (89.1)	.622[b]
I2A5	8 (9.0)	4 (9.3)	4 (8.7)	
Cytarabine	1 (1.1)	0 (0)	1 (2.2)	
Hypertension (n, %)				
Yes	5 (5.0)	2 (4.7)	3 (6.5)	1.000[b]
No	84 (94.4)	41 (95.3)	43 (93.5)	
Diabetes (n, %)				
Yes	6 (6.7)	5 (11.6)	1 (2.2)	.103[b]
No	83 (93.3)	38 (88.3)	45 (97.8)	
CKD (n, %)				
Yes	3 (3.4)	2 (4.7)	1 (2.2)	.608[a]
No	86 (96.6)	41 (95.3)	45 (97.8)	
Admission days	31.7 ± 12.0	30.7 ± 7.3	32.7 ± 15.2	.492[a]
Bacteraemia				
Yes	20 (22.5)	9 (20.9)	11 (23.9)	.803[a]
No	69 (77.5)	34 (79.1)	35 (76.1)	

PICC, peripherally inserted central catheter; IV, intravenous line; M, male; F, female; CKD, chronic kidney disease.

Data are shown as mean ± SD where appropriate.

[a]Mann–Whitney U-test.

[b]Fisher's exact test.

A reliable central venous access device is extremely important for treatment of cancer patients. Appropriate central venous access devices not only facilitate administration of chemotherapeutic agents and antibiotics but also provide a route for hydration and blood transfusion. Types of chemotherapy, the duration of the treatment and the ease of care of the catheter are the key factors in choosing the optimal central venous access device for use in cancer patients (Biffi, Toro, Pozzi, & di Carlo, 2014). In the past, an implantable port and centrally inserted external catheter were the conventional central venous access devices. However, peripherally inserted central catheters (PICCs) have increasingly been used for intermediate-term access over the last few years (Woller, Stevens, & Evans, 2015).

Compared with conventional central venous access devices, PICC has the advantages of easier insertion and removal (Johansson, Hammarskjold, Lundberg, & Arnlind, 2013). These advantages could be further applied to AML patients, because these patients have a profound tendency to bleed, have an immunocompromised status and poor wound-healing ability. Even though PICC is a feasible and safe alternative to conventional central venous access devices for patients with haematologic malignancies (Morano et al., 2015), its clinical application and safety for use in induction chemotherapy in newly diagnosed AML patients remain unclear and require further investigation.

Therefore, this study compared the feasibility and safety of PICCs and conventional peripheral intravenous (IV) lines in newly diagnosed
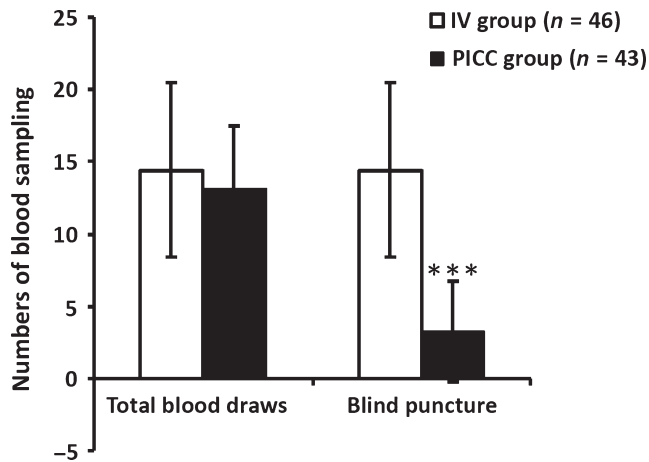
FIGURE 1 The average number of total blood samplings in the peripherally inserted central catheter (PICC) group and the intravenous (IV) line group were 13.2 ± 4.2 and 14.4 ± 6.0, respectively ($p = .271$). However, the number of blind punctures performed in the PICC group and IV line group were 3.3 ± 3.6 and 14.4 ± 6.0, respectively. Patients in the PICC group experienced significantly fewer blind punctures than those in the IV line group ($p = .000$). ***$p < 0.001$.

AML patients during induction chemotherapy. This study also investigated the quality of life of these patients by comparing the numbers of blind punctures required for blood sampling in these AML patients.

2 | METHODS

2.1 | Patients

The Institutional Review Board of Taichung Veterans General Hospital approved this study. Informed consent was waived due to the retrospective study design. Briefly, the medical records of 355 newly diagnosed adult AML patients, attending this institution from January 2004 to December 2014, were reviewed. To exclude possible confounding factors, patients with acute promyelocytic leukaemia ($n = 25$), treatment-associated AML ($n = 2$), AML with multiple lineage dysplasia ($n = 43$), or who were infected with human immunodeficiency virus ($n = 1$), or who had not achieved complete remission after the first induction ($n = 86$) and who were not receiving intent-to-cure chemotherapy ($n = 109$) were excluded. Finally, a total of 89 AML patients were included.

Our study cohort comprised 45 men and 44 women, with a mean age of 47.8 ± 14.4 years. To compare the feasibility and safety of PICC to those of conventional peripheral IV lines during induction chemotherapy in AML, patients were further stratified into a PICC group (January 2008 to December 2014; $n = 43$) and IV line group (January 2004 to July 2014; $n = 46$), respectively.

2.2 | PICC placement

Peripherally inserted central catheters were inserted according to the manufacturer's instruction. Briefly, a Groshong NXT ClearVue 4F Single-Lumen PICC (Bard Access Systems, Salt Lake City, UT, USA) was placed using the modified Seldinger technique into the veins

above the antecubital fossa with ($n = 36$) and without ($n = 7$) ultrasound guidance. The final position of the tip of the PICC was confirmed to be in the superior vena cava by chest X-ray. Only trained physicians were allowed to perform PICC insertion. Transparent dressings were changed weekly and if needed. Blood sampling from the PICC for routine tests and blood culture was permitted.

2.3 | Variable definitions

I3A7 (idarubicin, 12 mg m^{-2} day^{-1}, from day 1 to day 3; cytarabine, 100 mg m^{-2} day^{-1}, from day 1 to day 7) was considered to be the standard regimen for induction chemotherapy. I2A5 (idarubicin, 12 mg m^{-2} day^{-1}, from day 1 to day 2; cytarabine, 100 mg m^{-2} day^{-1}, from day 1 to day 5) and cytarabine alone were considered to be regimens with reduced intensity. Admission days were defined as the period between the day of chemotherapy initiation and the day of absolute neutrophil count >1000/μl. In terms of blood sampling, patients with PICC could obtain their blood samples either via the PICC or via blind puncture, as needed. In contrast, blind puncture was the only way to obtain the blood samples in patients with conventional peripheral IV catheters. The number of blood samplings was determined by counting the number of times blood tests were performed. Failure of blood sampling by blind puncture was not counted.

2.4 | Statistical analysis

The patients' clinical parameters were compared using the Mann–Whitney U-test and Fisher's exact tests, as appropriate. Data are expressed as the mean ± SD, where appropriate. Cox proportional-hazards regression was performed to evaluate risk factors for bacteraemia by univariate analysis. $p < .05$ was considered to indicate statistical significance. All statistical analyses were performed using SPSS software, version 20.0 (SPSS, Chicago, IL, USA).

3 | RESULTS

3.1 | Patients' clinical characteristics comparisons

The patients' clinical characteristics are summarised in Table 1. Briefly, the average age for patients in PICC and IV line groups were not significantly different (46.7 ± 14.4 and 48.9 ± 14.5, respectively; $p = .648$). The two groups of patients had similar initial leucocyte counts ($p = .786$), haemoglobin levels ($p = .718$) and platelet counts ($p = .825$). The incidence of hypertension ($p = 1.000$), diabetes ($p = .103$) and chronic kidney diseases ($p = .608$) were not significantly different between the groups.

3.2 | PICC decreases the numbers of blind blood punctures required in AML patients undergoing induction chemotherapy

Frequent blood tests are required during AML treatment; however, profound thrombocytopenia and an immunocompromised status may

TABLE 2 Identified pathogens for bacteraemia

Pathogens	PICC group (n = 9)	IV group (n = 10)
Acinetobacter iwoffii	0	1
Bacillus cereus	0	1
Candida species	2	2
Escherichia coli	1	0
Klebsiella pneumoniae	3	3
Pseudomonas aeruginosa	2	1
Staphylococcus epidermidis	1	2

PICC, peripherally inserted central catheter; IV, intravenous line.

TABLE 3 Univariate analysis for bacteraemia

	OR	95% CI	p
Age	1.02	0.98–1.06	0.296
Gender			
Male vs. female	0.85	0.31–2.35	0.754
Regimen dosage			
Reduced vs. standard	0.43	0.05–0.37	0.441
Route			
PICC vs. IV line	0.95	0.35–2.63	0.926
Diabetes			
Yes vs. no	1.94	0.33–11.5	0.465
CKD			
Yes vs. no	8.12	0.33–94.87	0.095

CKD, chronic kidney disease; IV, intravenous line; PICC, peripherally inserted venous catheter; OR, odds radio; CI, confident interval.

TABLE 4 Causes of removal of peripherally inserted central catheter

	n (%)	Duration (days)
Total	43 (100.0)	24.0 ± 7.0
Treatment complete	33 (76.7)	26.8 ± 5.0
Local infection	4 (9.3)	15.8 ± 6.3
Systemic infection	3 (7.0)	19.7 ± 5.5
Phlebitis	2 (4.7)	10.0 ± 2.8
Others	1 (2.3)	14

Data are shown as mean ± SD.

increase the risks of bleeding and local infection after this procedure. Therefore, we investigated whether the use of a PICC could decrease the number of blind punctures required for blood sampling in AML patients during their induction chemotherapy. The results are shown in Figure 1. The average number of total blood samplings performed in the PICC and IV line groups were 13.2 ± 4.2 and 14.4 ± 6.0, respectively ($p = .27$). However, the number of blind punctures required in the PICC and IV line groups was 3.3 ± 3.6 and 14.4 ± 6.0, respectively, which was significantly different ($p = .000$).

3.3 | Safety of PICC in AML patients

The number of days patients in the PICC group and IV line group was admitted was 30.7 ± 7.3 and 32.7 ± 15.2, respectively ($p = .492$). In the PICC group, 20.9% (9/43) of patients had bacteraemia, while 23.9% (11/46) patients in the IV lines had bacteraemia, which was not significantly different ($p = .803$; Table 1). The identified pathogens for bacteraemia are shown in Table 2. Gram-negative bacillus remained the major pathogens in both groups.

To investigate the risk factors for bacteraemia in AML patients during their first induction chemotherapy, univariate analysis was conducted; data are shown in Table 3. We found that the age ($p = .296$), gender ($p = .754$), regimen intensity ($p = .441$), and the incidence of diabetes ($p = .465$) and chronic kidney disease ($p = .095$) were not associated with bacteraemia in AML patients undergoing induction chemotherapy. In addition, the odds ratio of bacteraemia in the PICC vs. IV line was 0.95 (95% confidence interval: 0.35–2.63), suggesting that the use of PICC was not associated with an increased incidence of bacteraemia than the use of an IV line ($p = .926$). Because no variables were identified that could be associated with bacteraemia by univariate analysis, we did not perform multivariate analysis.

3.4 | Feasibility of PICC in AML induction chemotherapy

The duration for PICC placement in our study cohort was 24.0 ± 7.0 days (Table 4). In our study, 76.7% (33/43) of patients removed their PICC because their treatment had been completed. Only seven patients (7/43, 16.3%) needed to remove their PICC because of infection. Among these seven patients, four removed their PICC due to local infection. The average duration for PICC placement in these patients was 15.8 ± 6.3 days. Another three patients needed to remove their PICC because of systemic infection. Duration of PICC placement in these three patients was 19.7 ± 5.5 days. Interestingly, no PICC-associated thrombosis was found in this study.

3.5 | Technique for PICC insertion

We also studied whether ultrasound-guided PICC insertion was superior to PICC insertion by blind puncture. In this study cohort, the incidence of bacteraemia in AML patients who received ultrasound-guided PICC insertion ($n = 36$) and those who received PICC insertion by blind puncture ($n = 7$) was not significantly different (22.2% vs. 14.3%, $p = 1.000$; Table 5). However, hypertension ($p = .023$) and chronic kidney disease ($p = .023$) were more common in patients who received blind-puncture PICC insertion. Cox proportional-hazards regression was not performed because of the low patient numbers.

4 | DISCUSSION

We here found that PICC significantly decreased the number of blind punctures required for blood sampling in AML patients, undergoing

TABLE 5 Comparison of patients' clinical characteristics

	Ultrasound guided (n = 36)	Blind puncture (n = 7)	p
Age (years)	46.3 ± 14.1	48.7 ± 16.9	.640[a]
Gender (n, %)			
M	19 (52.8)	3 (42.9)	.698[b]
F	17 (47.2)	4 (57.1)	
Leucocyte (no./μl)	51,882.5 ± 58,709.5	24,867.1 ± 17,216.9	.573[a]
Haemoglobin (g/dl)	8.1 ± 2.0	7.7 ± 1.5	.687[a]
Platelet (no./μl)	71,527.8 ± 74,424.5	63,000.0 ± 43,611.9	.910[a]
Subtypes (n, %)			
M1	2 (5.6)		.266[b]
M2	23 (63.9)	2 (28.6)	
M4	10 (27.8)	3 (42.9)	
M5	1 (2.8)	2 (28.6)	
M6	0 (0)	0 (0)	
M7	0 (0)		
Regimens (n, %)			
I3A7	33 (91.7)	6 (85.7)	0.523[b]
I2A5	3 (8.3)	1 (14.3)	
Hypertension (n, %)			
Yes	0 (0)	2 (28.6)	0.023[b]
No	36 (100.0)	5 (71.4)	
Diabetes (n, %)			
Yes	3 (8.3)	2 (28.6)	0.180[b]
No	33 (91.7)	5 (71.4)	
CKD (n, %)			
Yes	0 (0)	2 (28.6)	0.023[b]
No	36 (100.0)	5 (71.4)	
Admission days	30.1 ± 7.0	33.7 ± 8.8	.292[a]
Bacteraemia (n, %)			
Yes	8 (22.2)	1 (14.3)	1.000[b]
No	28 (77.8)	6 (85.7)	

CKD, chronic kidney disease.
[a]Mann–Whitney U-test.
[b]Fisher's exact t-test.
Data are shown as mean ± SD where appropriate.

induction chemotherapy. Increasingly, data have suggested that not only the quality of life but also physical function improves over time in AML patients treated with intensive chemotherapy (Alibhai et al., 2015). Frequent blood sampling appears to be unavoidable in AML patients who undergo chemotherapy with the intention to cure, but only few studies have focused on the negative impact, thereof, on patients' quality of life. Our study demonstrated that AML patients who achieved complete remission by induction chemotherapy require an average of about 15 blood samplings. Notably, the patients with PICC only underwent an average of 3.3 ± 3.6 blind punctures for blood sampling, suggesting that PICC could improve the quality

of life of AML patients by reducing the number of blind punctures required.

We also investigated whether the PICC itself or blood sampling via the PICC resulted in increased complications. The study by Patel et al. (2014) demonstrated that compared with subcutaneously implanted port-chamber catheters, IV chemotherapy via PICC lines was associated with a higher risk of complications in patients with non-haematological malignancies. Although Morano et al. (2015) showed that PICCs are a useful alternative to conventional central venous access devices in patients with haematological malignancies, the feasibility and safety of PICC during induction chemotherapy to AML patients was unclear. In our study, more than 70% of the PICCs were removed because induction chemotherapy had been completed rather than because of infection. Moreover, compared with conventional IV lines, the use of PICCs did not increase the risk of bacteraemia in AML patients (odds ratio: 0.95; p = .926).

Catheter-associated thrombosis is another issue of concern. The study by Nolan, Yadav, Cawcutt, and Cartin-Ceba (2015) revealed that the incidence of PICC-related deep vein thrombosis is 4% in the medical intensive care unit. This incidence seemed higher than that observed for central venous catheters (1%), although not statistically significantly (p = .055). These data were further supported by the findings of Greene, Flanders, Woller, Bernstein, and Chopra (2015), which showed that PICCs are indeed associated with higher incidences of deep vein thrombosis over the upper and lower extremities. Interestingly, no thrombotic events were reported in our study cohort. Our findings were partially supported by the study from del Principe et al. (2013), which revealed that local infection is a risk factor that increases the incidence of central venous catheter-associated thrombosis. Only 9.3% of patients in our study cohort experienced local infection. Among our patients who experienced local infection over the PICC insertion site, the duration of PICC placement had been only 15.8 ± 6.3 days. Early PICC removal may largely decrease the chance of catheter-associated deep vein thrombosis. Moreover, a previous study had shown that Taiwanese myeloma patients have a low incidence of thromboembolism (Wu, Yeh, Chen, Su, & Chen, 2012). Similar results have been found in breast cancer patients (Chen et al., 2014), suggesting that differences in genetic background should be taken into consideration. In addition, profound thrombocytopenia in AML patients could be another possibility for the low incidence of thrombosis in our study cohort.

The majority of the patients (35/43, 83.7%) in our study underwent the indwelling PICC procedure, guided by ultrasound. The incidence of bacteraemia was not significantly different between patients receiving ultrasound-guided and those receiving blind puncture-based PICC insertion (22.2% vs. 14.3%, p = 1.000; Table 5); the incidence of other complications, however, was not analysed in this study. A randomised control study has shown that PICC insertion using ultrasound with the modified Seldinger technique reduces complications and improves patients' comfort (Li et al., 2014). The ultrasound-guided technique should be used for placement of indwelling PICCs, particularly in AML patients.

The major limitations of this study were the low patient number and the retrospective study design. In addition, to reduce possible

confounding factors, only patients with de novo AML and achieving complete remission were included and analysed. These inclusion criteria may not be capable of fully reflecting the real-world scenario, because according to our study, 36.3% (129/355) of patients would be excluded. Trials with prospective and randomised control design, including not only patients with de novo AML but also patients with treatment-associated AML, AML with multilineage dysplasia and patients who had not achieved complete remission after induction therapy are required to overcome these limitations.

In conclusion, our study demonstrated that the use of a PICC increased the quality of life in AML patients during their induction chemotherapy by reducing the number of blind punctures required for blood sampling. The incidence of bacteraemia in patients with PICCs was also comparable to that in patients with conventional IV lines. Thrombosis might not be a common complication of PICCs in AML patients. Taken these data together, PICC is a feasible and safe device for induction chemotherapy in AML patients.

CONFLICT OF INTEREST

The authors declare no conflict interest.

REFERENCES

Alibhai, S. M., Breunis, H., Timilshina, N., Brignardello-Petersen, R., Tomlinson, G., Mohamedali, H.,... Brandwein, J. M. (2015). Quality of life and physical function in adults treated with intensive chemotherapy for acute myeloid leukemia improve over time independent of age. *Journal of Geriatric Oncology*, *6*, 262–271.

Biffi, R., Toro, A., Pozzi, S., & di Carlo, I. (2014). Totally implantable vascular access devices 30 years after the first procedure. What has changed and what is still unsolved? *Supportive Care in Cancer*, *22*, 1705–1714.

Burnett, A., Wetzler, M., & Lowenberg, B. (2011). Therapeutic advances in acute myeloid leukemia. *Journal of Clinical Oncology*, *29*, 487–494.

Chen, T. W., Chen, H. M., Lin, C. H., Huang, C. S., Cheng, A. L., Lai, M. S., & Lu, Y. S. (2014). No increased venous thromboembolism risk in Asian breast cancer patients receiving adjuvant tamoxifen. *Breast Cancer Research and Treatment*, *148*, 135–142.

Greene, M. T., Flanders, S. A., Woller, S. C., Bernstein, S. J., & Chopra, V. (2015). The association between PICC use and venous thromboembolism in upper and lower extremities. *American Journal of Medicine*, *128*(e1), 986–993.

Johansson, E., Hammarskjold, F., Lundberg, D., & Arnlind, M. H. (2013). Advantages and disadvantages of peripherally inserted central venous catheters (PICC) compared to other central venous lines: A systematic review of the literature. *Acta Oncologica*, *52*, 886–892.

Li, J., Fan, Y. Y., Xin, M. Z., Yan, J., Hu, W., Huang, W. H.,... Qin, H. Y. (2014). A randomised, controlled trial comparing the long-term effects of peripherally inserted central catheter placement in chemotherapy patients using B-mode ultrasound with modified Seldinger technique versus blind puncture. *European Journal of Oncology Nursing*, *18*, 94–103.

Lynch, R. C., & Medeiros, B. C. (2015). Chemotherapy options for previously untreated acute myeloid leukemia. *Expert Opinion on Pharmacotherapy*, *16*, 2149–2162.

Morano, S. G., Latagliata, R., Girmenia, C., Massaro, F., Berneschi, P., Guerriero, A.,... Foa, R. (2015). Catheter-associated bloodstream infections and thrombotic risk in hematologic patients with peripherally inserted central catheters (PICC). *Supportive Care in Cancer*, *23*, 3289–3295.

Nolan, M. E., Yadav, H., Cawcutt, K. A., & Cartin-Ceba, R. (2015). Complication rates among peripherally inserted central venous catheters and centrally inserted central catheters in the medical intensive care unit. *Journal of Critical Care*, *31*, 238–242.

Patel, G. S., Jain, K., Kumar, R., Strickland, A. H., Pellegrini, L., Slavotinek, J.,... Karapetis, C. S. (2014). Comparison of peripherally inserted central venous catheters (PICC) versus subcutaneously implanted port-chamber catheters by complication and cost for patients receiving chemotherapy for non-haematological malignancies. *Supportive Care in Cancer*, *22*, 121–128.

del Principe, M. I., Buccisano, F., Maurillo, L., Venditti, D., Cefalo, M., Sarlo, C.,... Venditti, A. (2013). Infections increase the risk of central venous catheter-related thrombosis in adult acute myeloid leukemia. *Thrombosis Research*, *132*, 511–514.

Reilly, J. T. (2005). Pathogenesis of acute myeloid leukaemia and inv(16)(p13;q22): A paradigm for understanding leukaemogenesis? *British Journal of Haematology*, *128*, 18–34.

Robak, T., & Wierzbowska, A. (2009). Current and emerging therapies for acute myeloid leukemia. *Clinical Therapeutics*, *31*(Pt 2), 2349–2370.

Vardiman, J. W., Thiele, J., Arber, D. A., Brunning, R. D., Borowitz, M. J., Porwit, A.,... Bloomfield, C. D. (2009). The 2008 revision of the World Health Organization (WHO) classification of myeloid neoplasms and acute leukemia: Rationale and important changes. *Blood*, *114*, 937–951.

Woller, S. C., Stevens, S. M., & Evans, R. S.(2015). The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) initiative: A summary and review of peripherally inserted central catheter and venous catheter appropriate use. *Journal of Hospital Medicine*, *163*, S1–S39.

Wu, S. Y., Yeh, Y. M., Chen, Y. P., Su, W. C., & Chen, T. Y. (2012). Low incidence of thromboembolism in relapsed/refractory myeloma patients treated with thalidomide without thromboprophylaxis in Taiwan. *Annals of Hematology*, *91*, 1773–1778.