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Placement and management of Peripherally Inserted Central Catheters (PICC): Which complications? A retrospective 2-year single-Centre experience.

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ABSTRACT

Introduction: Peripherally inserted central catheters (PICCs) are catheters placed in the central venous system, through a peripheral vein. PICCs' are devices designed for intermediate to long-term use, which are usually implanted for long periods and may be subjected to mechanical and infectious complications as well as thrombosis and acute bleeding during insertion or maintenance procedures.
The aim of this study is to investigate and describe the various types of complications resulting from placement and management of PICC catheters in patients admitted to the SS Antonio e Biagio e Cesare Arrigo Hospital wards.
Methods: Data was collected from the medical records of patients undergoing PICC implantation from June 2018 to December 2019.
Results: Data from 320 patients were included in the study. 55% of patients did not develop complications. 34% of all patients with complications had minor complications and 86% of devices were not removed before the end of treatment.
Conclusions: PICCs' appear to be safe devices for use, with acceptably low rates of infectious or thrombotic complications. The most common complications have been minor causes, potentially avoidable with adequate prevention measures.

Background

Peripherally Inserted Central Catheter (PICC) are central venous access devices (catheters) which are placed using ultrasound guidance in the peripheral upper arm vein, often placed just above or just below the elbow (i.e. basilica or brachial vein) with the catheter tip placed at the cava arterial junction (Schnapauff et al., 2020).

The use of PICC's responds to the need to provide a valid medium-long term central venous device that enables prolonged and/or intermittent treatments with medicines otherwise harmful or toxic (eg. Cancer chemotherapy) for small veins such as those of the upper limbs (Cotogni & Pittiruti, 2014). The Centers for Disease Control and Prevention (CDC) of Atlanta guidelines do not define the average maximum longevity in situ of the device nevertheless; the average time in situ ranges from 10 days and 6 months (Hatakeyama et al., 2011; Jonczyk et al., 2018).
The device can be single, double or triple lumen with a length that ranges from 50 cm to 60 cm. The PICC is equipped with a non-traumatic anchoring device of clear medical adhesive tape without the use of surgical sutures; securement, sometimes called stabilization, which prevents catheter movement and therefore secondary displacement, is very important in order to reduce infectious complications (Yamamoto et al., 2002).
It is essential to evaluate correctly the patients' care path from a diagnostic-therapeutic point of view, since this enables to select the most suitable and correct device for the patient. Catheter choice should be based on treatment duration, level of care, patient competence and patient comorbidity, considering these items may potentially contribute to other catheter complications.
Medical staff (eg. surgeons, anaesthetists etc.) or specially trained registered nurses are authorised to place PICCs' (Robert et al., 2000; Sherertz et al., 2000).
PICCs have become a valuable devices for adults and children as it offers long-term intravenous access and several advantages, including easy placement, short procedure time (Cotogni & Pittiruti, 2014; Ong et al, 2006), abolition of risks associated with central venipuncture (subclavian and jugular vents), preservation of the peripheral vascular system, reduction of infectious complications with low risk of Catheter Related Blood Stream Infection (CRBSI) (Grau et al., 2017; O'Grady et al., 2011) and high patient satisfaction rate (Liem et al., 2012).
PICCs on the other hand may have some disadvantages and limits such as the non-applicability in the presence of impaired veins. Not all PICC's can be used for the infusion of high-pressured contrast, since not all are adequate and they also may not be suitable in the case of special arm conditions (eg. paresis, local skin infections, presence of orthopaedic fixation materials and devices with blockage of the upper limb, severe local burns, axillary lymphadenectomy) (Cotogni & Pittiruti, 2014). Even though PICCs may remain in situ long term, complications on the main line due to blood stream infections (CLABSI), thrombosis and acute bleeding during placement or maintenance, can arise (Badheka et al., 2019; Chopra et al., 2012). To minimise complications it is essential to select an appropriately sized catheter with the least number of lumens necessary for the vein and to ensure its patency (Templeton et al. 2008). The number of lumens is an important predictor of infectious and thrombotic complications for PICCs; often the increase in number of lumens corresponds to an increase in the catheter calibre with an increased thrombotic risk (Chopra et al., 2014b). The ratio between catheter diameter and vein diameter affects the flow rate and if wrongly addressed predisposes to thrombotic risk (Nifong et al., 2011). Furthermore, bloodstream infection associated with PICCs correlates with the length of hospitalization (Chopra et al., 2014a).
Performing proper dressing and nursing management of the PICC is one of the basic requirements to prevent infectious complications.
The aim of this study is to monitor the various types of complications arising from PICC catheter placement and management in patients admitted to the wards of the SS. Antonio e Biagio e Cesare Arrigo Hospital of Alessandria, dividing them into categories.

Materials and Methods

The study, examined the medical records of patients who underwent PICC catheter implantation during the period from June 2018 to December 2019. All patients who were admitted to the various AO facilities during the above period and underwent PICC implantation regardless of pathology were included. Patients with PICCs placed at other institutions were excluded due to lack of data on the device.

The study began after the approval of the Intercompany Ethics Committee and subsequent resolution. The acquisition of informed consent from patients was obtained in writing on special forms, after exhaustive description and sharing of the study protocol.
Data extracted from medical records included demographic data, implantation ward, device characteristics, implanted vein, implant operator, complications encountered and removals.
The data collected from the analysis of the medical records were then uploaded to the online computerised platform "Electronic Data Capture" (REDCap), in use at the promoting centre and adapted to the specificities of the study.

Statistical Analysis

The demographic, clinical and technical characteristics were summarised using descriptive statistics. In particular, absolute frequencies and percentages were used for the qualitative variables; the arithmetic mean and standard deviation were used as summary indices for the quantitative variables in the case of a Gaussian distribution of variables, while the median and interquartile range were used in the case of a non-Gaussian distribution of variables.
The estimate of the proportion of adverse events was considered on a 95% confidence interval for proportions (normal approximation).
All statistical analyses were performed using Statistical Package version 25 IBM SPSS® for Windows.

Results

Data of 320 patients were included in the study, 156 males (48.8%), 164 females (51.2%); mean age (± SD) 65.64 (± 14.69); males 64.81 (± 14.82), females 66.43 (± 14.57). 85.8% of admissions (272) concerned residents in the province of Alessandria (data available for n=317).

The majority of admissions came from the Oncohaematology Day Hospital (100, 31.3%), Oncology (71, 22.2%), General Surgery for oncology (40, 12.5), Haematology (37, 11.6%), Infectious Diseases (30, 9.4%) (data available for 278 patients). 66.3% of the patients (209) were inpatients, 33.7% (106) in Day Hospital (Table 1).

	N	%
Gender		
Males	156	8.8
Famales	164	51.2
Age		
Under 50	49	15.3
50 - 65 years	103	32.2
66 - 75 years	69	21.6
Over 75	99	30.9
Ward		
Oncology Day Hospital	100	31.3

	N	%
Admission		
Day hospital	106	33.7
In-patient	209	66.3
PICC implantation ward		
Onco-hematology Day Hospital	165	53.9
Radiology/imaging	130	42.5
Other ward	11	3.6
Healthcare Operator who implanted the PICC		
Nurse	284	90.2
Doctor	31	9.8

Oncology	71	22.2
Hematology	37	11.6
General Surgical Oncology	40	12.5
Infectious Diseases	30	9.4
Geriatrics	16	5.0
Pneumology	11	3.4
Neurology /Nefrology	8	2.5
General Medicine / Rheumatology	3	0.9
Neurosurgery	1	0.3
Emergency medical unit/emergency ward/casualty	1	0.3
Cardiac surgery/ open heart surgery Cardiology	1	0.3
Urology	1	0.3

PICC material		
polyurethane	273	85.8
silicone	39	12.3
other	6	1.9
PICC removal		
At the end of treatment	261	85,6
Before the end of treatment	44	14,4
Reasons for PICC removal		
accidental	5	11,4
Complications	39	88,6

Table 1 Patient characteristics

Insertion took place in the Onco-haematology Day Hospital (165, 53.9%), in Radiology (130, 42.5%), in other wards 3.6% (11).
In 99.6% (237) of patients, the ultrasound-guided method was used, while in 0.4% (1) it was radio-guided. The mean PICC retention time was 25.27 days (±28.58). A chest X-ray was performed in 87.2% (273) of patients. Nurses performed 90.2% of implants (284), doctors 9.8% (31). Devices were inserted in the basilic vein (219, 69.5%), brachial vein (88, 27.9%), cephalic vein (8, 2.5%); in the right arm 86.4% (274), in the left 13.6% (43). The material of the inserted devices was polyurethane (273, 85.8%), silicone (39, 12.3%), other material (6, 1.9%).
The prevailing gauge was 5 French (212, 91%), 4 French (21, 9%); most frequent gauges were 18 (148, 71.5%) and 16 (57, 27.5%); number of lumens was 1 in 96% of cases (242), 2 in 4% (10); median length cm.45 (IQR=4). Catheter fixation was performed in the majority of cases with stat-lock (148, 47.6%) or grip-lock device (115, 37%), 12.2% (38) with steri-strip fixation, with other 3.2% (10). The dressing was polyurethane - tegaderm (216, 68.4%), sterile - cosmopor E (91, 28.8%), other material (9, 2.8%).
The complications reported were phlebitis (25, 7.8%), pain (24, 7.5%), occlusion (16, 5%), sepsis (13, 4.1%), bleeding (12, 3.8%), thrombosis (9, 2.8%), catheter rupture (4, 1.3%). 55% of the 320 patients had no complications (176). 15.6% of the complications detected (50) were minor complications (representing 34.7% of all patients in whom complications were found) (Table 2).

Complications	N	%	range		margine 95%		MEAN AGE ± SD
none	176	55,0	49,8	60,8	+-	5,5	67.02 ± 15.55
thrombosis	9	2,8	1,0	4,6	+-	1,8	72.44 ± 14.09
embolism	0	0,0	-	-	+-	-	-
phlebitis	25	7,8	4,8	10,7	+-	3,0	63.28 ± 13.08
sepsis	13	4,1	1,9	6,3	+-	2,2	66.00 ± 12.25
Rupture/breakage of the catheter	4	1,3	0,1	2,5	+-	1,2	61.00 ± 21.73
pain	24	7,5	4,6	10,4	+-	2,9	59.21 ± 11.73
bleeding	12	3,8	1,7	5,9	+-	2,1	63.58 ± 17.92
Occlusion/blockage	16	5,0	2,6	7,4	+-	2,4	65.81 ± 11.66
death	0	0,0	-	-	+-	-	-
minor complications/severities	50	15,6	11,6	19,6	+-	4,0	64.52 ± 13.66

Table 2 Prevalence rate of PICC complications

85.6 % of the devices (261) were not removed before the end of therapy. The removal due to complications accounted for 88.6% (39) of the 44, while 11.4% (5) were accidental. In addition, only 27.1% of patients who suffered complications required unplanned PICC removal.

Considering the type of patients according to the hospital ward of origin, the percentage of patients in whom no complication had been observed, was 73. 2% (52 out of 71) for Oncology, 75% (12 out of 16) for Geriatrics, 60% (18 out of 30) for Infectious Diseases, 54.1% (20 out of 37) for Hematology, 52.5% (21 out of 40) for General Surgery with oncological focus and 42% (42 out of 100) among those coming from Onco-hematology Day Hospital (p=0.005).

The average age of patients with pain onset was 59.21 years (± 11.73) vs. 66.16 (± 14.80) of those without pain onset (p=0.013).

There was a more significant prevalence of phlebitis in patients from General Surgery with an oncological focus (15%, 6 out of 40) compared to the other wards which had a significant number of cases (p<0.001).

The prevalence rate of complications was lower in devices implanted by nurses than in those implanted by doctors: 57.4% with no complications vs. 32.3% (p=0.008).

Bleeding was more frequent in implants performed by doctors 12.9% vs. 2.5% in implants performed by nurses (p=0.003); the same was true for occlusion, 19.4% vs. 3.5% (p<0.001). (Table 3)

Complications	Healthcare Operator who implanted the PICC			
	Nurse (n=284)		Doctor/Radiologist (n=31)	
	N	%	N	%
none	163	57,4%	10	32,3%
thrombosis	7	2,5%	2	6,5%
phlebitis	20	7,0%	5	16,1%
sepsis	11	3,9%	2	6,5%
Rupture/breakage of the catheter	3	1,1%	1	3,2%
pain	23	8,1%	1	3,2%
bleeding	7	2,5%	4	12,9%
Occlusion/blockage	10	3,5%	6	19,4%
minor complications/severities	48	16,9%	1	3,2%

Table 3. Operator who performed PICC implant / Complications

Discussion

The use of PICCs has increased significantly due to several advantages found, such as lower risk of mechanical complications, ease of insertion and better patient tolerance compared to other CVCs (Johansson et al., 2013).

The study underlines the settings for which PICC implantation is most required represented by oncology facilities, where its use plays a key role in the hospital setting management of these patients (Ajenjo et al., 2011). Data collected in the study showed that, out of 320 patients, the majority of complications were present in the Oncohaematology Day Hospital (DH), in the Oncology ward in the General Surgery for oncology ward, in the Haematology ward, which are the major centres of device placement.

Complications such as skin redness, phlebitis, thrombosis, bleeding, occlusion, pain, embolism, sepsis and catheter rupture are usually associated with the use of peripheral central catheters (Chopra et al., 2013). What was observed within this study was that minor complications were the most prevalent complications, followed by cases of phlebitis and pain distributed almost equally in patients of different genders.

Minor complications are those that can be corrected by secondary treatment and do not require removal of the PICC and include phlebitis of a catheterised vein, pain or bruising at the site, skin reactions to the dressing covering the insertion site, slow blood sampling or resistance during PICC flushing (Cotogni & Pittiruti, 2014).

Catheter occlusions were found more often in male patients than in female patients. 45% of patients presented at least one PICC-associated complication that is in line with literature data (Wallis et al., 2014).

Phlebitis cases were mostly present in patients coming from the Oncology ward and the oncology-oriented General Surgery ward; this finding may be related to the type of therapy of these patients, their clinical condition and the number of device placement attempts.

Occlusion is a complication that occurs more frequently in subjects previously admitted to the haematology and oncology-oriented General Surgery wards.

Subjects from the General Surgery ward had more cases of phlebitis, sepsis and catheter occlusion.

Day hospital patients were mainly associated with minor complications, phlebitis, occlusions, sepsis and bleeding; inpatients had more cases of phlebitis, catheter occlusions and bleeding. In contrast, catheter rupture was reported in small numbers (4 in inpatients). This is consistent with literature findings that correlates complications with the number of hospitalization days (Chopra et al., 2014a).
Approximately 14 % of PICCs were removed before the end of therapy and of these, 88 % were due to a complication; the overall rate of device failure is consistent with the results of previous studies (Bertoglio et al., 2012, 2013)
Despite a limited sample, which is a limitation of the study, the results provide an overview of the most common complications in PICC patients on which preventive interventions can be implemented. However, it is essential to extend the study to a larger number of patients in order to obtain reliable results and identify the patient population considered to be at high risk. The data obtained will allow the implementation of corrective actions to reduce specific complications. The study relied on data from nursing and medical records to identify complications, some of which may not have been reported. In addition, not all subjects had complete PICC information: no information was collected on the type of infused therapy that might be related to complications. The strength of this study was the inclusion of a large population of patients of different ages and diagnoses; in fact it assessed PICC complications among inpatients and outpatients, independently of the type of medication infused and the patients' condition.

Conclusions

In conclusion, this study identified PICC-related complications. PICCs appear to be safe devices to use, with acceptably low rates of infectious or thrombotic complications. Minor causes were the most common complications, potentially avoidable with appropriate preventive measures.
The development of specific prevention strategies and protocols in each PICC unit is essential. In addition, much future scientific investigation will depend on improving knowledge of best PICC practice to reduce patient morbidity, reduce healthcare costs and eliminate PICC-associated complications.

Conflicts of interest
The Authors declare that there is no conflict of interest.

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Bibliography

- Ajenjo, M. C., Morley, J. C., Russo, A. J., McMullen, K. M., Robinson, C., Williams, R. C., & Warren, D. K. (2011). Peripherally inserted central venous catheter-associated bloodstream infections in hospitalized adult patients. *Infection Control and Hospital Epidemiology*, *32*(2), 125–130. https://doi.org/10.1086/657942
- Badheka, A., Bloxham, J., Schmitz, A., Freyenberger, B., Wang, T., Rampa, S., Turi, J., Allareddy, V., Auslender, M., & Allareddy, V. (2019). Outcomes associated with peripherally inserted central catheters in hospitalised children: A retrospective 7-year single-centre experience. *BMJ Open*, *9*(8), e026031. https://doi.org/10.1136/bmjopen-2018-026031
- Bertoglio, S., Rezzo, R., Merlo, F. D., Solari, N., Palombo, D., Vassallo, F., Beltramini, S., & DeMaria, A. (2013). Pre-filled normal saline syringes to reduce totally implantable venous access device-associated bloodstream infection: A single institution pilot study. *The Journal of Hospital Infection*, *84*(1), 85–88. https://doi.org/10.1016/j.jhin.2013.02.008
- Bertoglio, S., Solari, N., Meszaros, P., Vassallo, F., Bonvento, M., Pastorino, S., & Bruzzi, P. (2012). Efficacy of normal saline versus heparinized saline solution for locking catheters of totally implantable long-term central vascular access devices in adult cancer patients. *Cancer Nursing*, *35*(4), E35-42. https://doi.org/10.1097/NCC.0b013e31823312b1
- Chopra, V., Anand, S., Krein, S. L., Chenoweth, C., & Saint, S. (2012). Bloodstream Infection, Venous Thrombosis, and Peripherally Inserted Central Catheters: Reappraising the Evidence. *The American Journal of Medicine*, *125*(8), 733–741. https://doi.org/10.1016/j.amjmed.2012.04.010
- Chopra, V., O'Horo, J. C., Rogers, M. A. M., Maki, D. G., & Safdar, N. (2013). The risk of bloodstream infection associated with peripherally inserted central catheters compared with central venous catheters in adults: A systematic review and meta-analysis. *Infection Control and Hospital Epidemiology*, *34*(9), 908–918. https://doi.org/10.1086/671737
- Chopra, V., Ratz, D., Kuhn, L., Lopus, T., Chenoweth, C., & Krein, S. (2014a). PICC-associated bloodstream infections: Prevalence, patterns, and predictors. *The American Journal of Medicine*, *127*(4), 319–328. https://doi.org/10.1016/j.amjmed.2014.01.001
- Chopra, V., Ratz, D., Kuhn, L., Lopus, T., Chenoweth, C., & Krein, S. (2014b). PICC-associated Bloodstream Infections: Prevalence, Patterns, and Predictors. *The American Journal of Medicine*, *127*(4), 319–328. https://doi.org/10.1016/j.amjmed.2014.01.001
- Cotogni, P., & Pittiruti, M. (2014). Focus on peripherally inserted central catheters in critically ill patients. *World Journal of Critical Care Medicine*, *3*(4), 80–94. https://doi.org/10.5492/wjccm.v3.i4.80
- Grau, D., Clarivet, B., Lotthé, A., Bommart, S., & Parer, S. (2017). Complications with peripherally inserted central catheters (PICCs) used in hospitalized patients and outpatients: A prospective cohort study. *Antimicrobial Resistance & Infection Control*, *6*(1), 18. https://doi.org/10.1186/s13756-016-0161-0
- Hatakeyama, N., Hori, T., Yamamoto, M., Mizue, N., Inazawa, N., Igarashi, K., Tsutsumi, H., & Suzuki, N. (2011). An evaluation of peripherally inserted central venous catheters for children with cancer requiring long-term venous access. *International Journal of Hematology*, *94*(4), 372–377. https://doi.org/10.1007/s12185-011-0928-2
- Hon, K., Bihari, S., Holt, A., Bersten, A., & Kulkarni, H. (2019). Rate of Catheter-Related Bloodstream Infections Between Tunneled Central Venous Catheters Versus Peripherally Inserted Central Catheters in Adult Home Parenteral Nutrition: A Meta-analysis. *JPEN. Journal of Parenteral and Enteral Nutrition*, *43*(1), 41–53. https://doi.org/10.1002/jpen.1421
- Johansson, E., Hammarskjöld, 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 (Stockholm, Sweden)*, *52*(5), 886–892. https://doi.org/10.3109/0284186X.2013.773072

- Jonczyk, M., Gebauer, B., Schnapauff, D., Rotzinger, R., Hamm, B., & Collettini, F. (2018). Peripherally inserted central catheters: Dependency of radiation exposure from puncture site and level of training. *Acta Radiologica (Stockholm, Sweden: 1987)*, *59*(6), 688–693. https://doi.org/10.1177/0284185117730101
- Liem, T. K., Yanit, K. E., Moseley, S. E., Landry, G. J., DeLoughery, T. G., Rumwell, C. A., Mitchell, E. L., & Moneta, G. L. (2012). Peripherally inserted central catheter usage patterns and associated symptomatic upper extremity venous thrombosis. *Journal of Vascular Surgery*, *55*(3), 761–767. https://doi.org/10.1016/j.jvs.2011.10.005
- *Linee guida INS 2016 trad.it_..pdf*. (s.d.). Recuperato 11 ottobre 2021, da https://gave-celt.it/nuovo/sites/default/files/uploads/Linee%20guida%20INS%202016%20trad.it_..pdf
- O'Grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S. O., Lipsett, P. A., Masur, H., Mermel, L. A., Pearson, M. L., Raad, I. I., Randolph, A. G., Rupp, M. E., & Saint, S. (2011). Guidelines for the Prevention of Intravascular Catheter-related Infections. *Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America*, *52*(9), e162–e193. https://doi.org/10.1093/cid/cir257
- Ong, B., Gibbs, H., Catchpole, I., Hetherington, R., & Harper, J. (2006). Peripherally inserted central catheters and upper extremity deep vein thrombosis. *Australasian Radiology*, *50*(5), 451–454. https://doi.org/10.1111/j.1440-1673.2006.01623.x
- Robert, J., Fridkin, S. K., Blumberg, H. M., Anderson, B., White, N., Ray, S. M., Chan, J., & Jarvis, W. R. (2000). The influence of the composition of the nursing staff on primary bloodstream infection rates in a surgical intensive care unit. *Infection Control and Hospital Epidemiology*, *21*(1), 12–17. https://doi.org/10.1086/501690
- Schnapauff, D., Maxeiner, A., Wieners, G., Denecke, T., Hamm, B., Gebauer, B., & Jonczyk, M. (2020). Semi-automatic prostatic artery detection using cone-beam CT during prostatic arterial embolization. *Acta Radiologica*, *61*(8), 1116–1124. https://doi.org/10.1177/0284185119891689
- Sherertz, R. J., Ely, E. W., Westbrook, D. M., Gledhill, K. S., Streed, S. A., Kiger, B., Flynn, L., Hayes, S., Strong, S., Cruz, J., Bowton, D. L., Hulgan, T., & Haponik, E. F. (2000). Education of physicians-in-training can decrease the risk for vascular catheter infection. *Annals of Internal Medicine*, *132*(8), 641–648. https://doi.org/10.7326/0003-4819-132-8-200004180-00007
- Wallis, M. C., McGrail, M., Webster, J., Marsh, N., Gowardman, J., Playford, E. G., & Rickard, C. M. (2014). Risk factors for peripheral intravenous catheter failure: A multivariate analysis of data from a randomized controlled trial. *Infection Control and Hospital Epidemiology*, *35*(1), 63–68. https://doi.org/10.1086/674398
- Yamamoto, A. J., Solomon, J. A., Soulen, M. C., Tang, J., Parkinson, K., Lin, R., & Schears, G. J. (2002). Sutureless securement device reduces complications of peripherally inserted central venous catheters. *Journal of Vascular and Interventional Radiology: JVIR*, *13*(1), 77–81. https://doi.org/10.1016/s1051-0443(07)60012-8