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Ultrasound and Fluoroscopy-assisted Central Venous Catheterisation: A Retrospective Evaluation of Device Survival and Complications in a Tertiary Care Setting

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ABSTRACT

Introduction: Central Venous Access Devices (CVADs) are indispensable in tertiary care for administering chemotherapy, parenteral nutrition, and haemodialysis. Image-guided insertion, particularly under Ultrasonography (USG) and fluoroscopy, has significantly reduced complications compared to landmark-based techniques. However, data on outcomes and complications in diverse patient populations remain limited.

Aim: To evaluate the technical success, device survival, and complications associated with image-guided CVAD insertions, focusing on patient demographics, catheter types, and risk factors.

Materials and Methods: A retrospective analysis was conducted on 100 patients who underwent CVAD placement in the Department of Interventional Radiology of a tertiary care setting, Pune, India, from January 2015 to June 2016. Data were collected using a structured case record form, including demographics, catheter types (tunneled, non-tunneled, Peripherally Inserted Central Catheters (PICC), ports), access sites (internal jugular, femoral, basilic veins), and complications (early: <24 hours; intermediate: 24 hours-30 days; late: >30 days). Technical success was defined as successful catheter placement with tip confirmation at the cavoatrial junction and functional patency. Statistical analysis included descriptive statistics (mean, SD, percentages) and device survival analysis (from insertion to removal or patient death).

Results: The study comprised 60 males and 40 females (mean age: 37.13±16.61 years). Tunneled catheters (Permacath) were most common (41%), followed by PICCs (36%). The right internal jugular vein was the preferred access site (61%). Technical success was achieved in 100% of cases. Device survival averaged 146.32±98.9 days (median: 135.5 days). Complications included infection (4%), catheter occlusion (2%), and tip migration (1%). Seven patients died during follow-up, none from catheter-related causes.

Conclusion: Image-guided Central Venous Catheter (CVC) insertion demonstrated excellent technical success rates. The right internal jugular vein was the safest access site, while infectious complications remained the most common adverse outcome despite relatively low occurrence rates. These findings support current practice standards while identifying areas for continued quality improvement.

Keywords: Catheter, Imaging, Internal jugular vein

INTRODUCTION

The CVC has emerged as an indispensable therapeutic modality in contemporary Indian healthcare, facilitating critical interventions ranging from chemotherapy administration to renal replacement therapy. The proliferation of advanced medical care across India's tertiary hospitals has precipitated a dramatic increase in CVAD utilisation [1]. This exponential growth reflects both India's expanding critical care infrastructure and the rising burden of chronic diseases requiring long-term vascular access. However, this increased utilisation has unmasked significant challenges in device-associated complications that carry particularly grave consequences in resource-constrained environments.

The transition from traditional landmark-based techniques to image-guided insertion represents one of the most transformative advances in Indian Interventional practice over the past decade. Contemporary data from the Indian Registry of Vascular Access (IRVA) reveals that USG guidance has reduced immediate mechanical complications by 68% in participating centers [2,3]. Nevertheless, a disturbing dichotomy persists, while premier institutions report outcomes comparable to global benchmarks, smaller hospitals and rural centers continue to experience complication rates 3-4 times higher, underscoring profound disparities in technology adoption and procedural expertise [4]. Fluoroscopic confirmation, though recognised as the gold standard for tip positioning, remains inaccessible to nearly 40% of Indian Intensive Care Unit (ICU) according to the Indian Intensive Care Case Mix and Practice Patterns Study (INDICAPS) [5].

The clinical ramifications of CVAD complications in the Indian context are particularly severe. A six-year multicenter study across 204 ICUs in India reported a Catheter-Related Bloodstream Infection (CRBSI) rate of 2.91/1,000 catheter-days, significantly higher than rates in industrialised countries [6]. These infections demonstrate alarming antimicrobial resistance patterns, with 68% of isolates showing multidrug resistance in the Indian Consensus of the management of Carbapenem-resistant Enterobacterales infection in Critically Ill patients (ICONIC) study [7]. PICCs are associated with an increased risk of Venous Thromboembolism (VTE) in cancer patients and hospitalised medical patients. Studies report varying incidence rates of Upper Extremity Deep Vein Thrombosis (UEDVT) in PICC users, ranging from 7.8-15% [8,9]. The economic burden is equally staggering, with CRBSIs significantly increasing hospitalisation costs and prolonging ICU stays [10,11].

Indian clinical practice exhibits several distinctive characteristics in CVAD management. The femoral vein remains a surprisingly common access site (utilised in 19-27% of insertions), reflecting both the high prevalence of cervical radiation cases in oncology and operator comfort factors [12]. Antimicrobial-impregnated catheters, while widely available, are used in only 28% of insertions due to cost constraints [1]. Perhaps most concerning is the documented

47% non compliance with maximal sterile barrier precautions in a nationwide audit of insertion practices [13].

This study of 100 consecutive image-guided CVAD placements at a high-volume Indian tertiary centre seeks to address critical knowledge gaps through three specific aims: First, to quantify the real-world advantage of combined ultrasound-fluoroscopy guidance over ultrasound alone in preventing malposition and early complications. Second, to compare the longitudinal performance of tunneled catheters versus PICCs in tropical hospital environments where microbial ecology and patient hygiene factors may differentially impact outcomes. Third, to characterise the timing and microbiology of infectious complications to optimise surveillance protocols. The present study findings aim to inform the development of context-specific guidelines that balance ideal practices with ground realities of Indian healthcare delivery.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Interventional Radiology at Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pune, india, after obtaining necessary approvals from the Institutional Ethics Committee. The study analysed 100 consecutive patients who underwent image-guided CVC insertion between January 2015 and June 2016. The research was conducted in compliance with Institutional protocols and ethical guidelines for retrospective studies.

Inclusion and exclusion criteria: Patient selection was based on comprehensive review of medical records, with inclusion criteria encompassing all patients who underwent CVAD placement during the study period. Exclusion criteria were applied to patients with incomplete medical records or those who had catheters placed outside the Interventional Radiology Department.

Study Procedure

Data collection was performed using a detailed case record form that systematically captured multiple parameters from patient files. The form included sections for demographic information such as age, sex, and file number, along with clinical details about underlying diseases and co-morbid conditions including hypertension, diabetes mellitus, and asthma.

The case record form specifically documented the history of previous CVADs, including the type of device (Permacath catheter, Mahurkar catheter, port, or PICC), access site (internal jugular vein, femoral vein, basilic vein, cephalic vein, or brachial vein), dates of insertion and removal, duration of use, and any complications experienced. For the current procedure, the form recorded detailed information about indications, categorised into therapeutic indications such as administration of chemotherapy, total parenteral nutrition, blood products, intravenous medications, intravenous fluids, performance of plasmapheresis, or haemodialysis, and diagnostic indications including establishing or confirming a diagnosis, establishing prognosis, monitoring treatment response, or repeated blood sampling.

Technical aspects of the procedure were thoroughly documented, including the category of catheter (tunneled catheter, non-tunneled catheter, port, or PICC), specific device type, number of lumens, size in French, and length in centimeters. The procedural description covered aseptic precautions, procedure room details, preprocedure antibiotic administration, anaesthesia type (general, sedation, or local), access site laterality (right or left-side), patient positioning (supine or prone), and image guidance modality (ultrasound guidance, fluoro guidance, or both). Additional technical details included access needle gauge, postprocedure imaging confirmation method (fluoroscopic confirmation or chest X-ray), and coagulation parameters including platelet count, International Normalised Ratio (INR), and Prothrombin Time (PT)/Activated Partial Thromboplastin Time (APTT) measured prior to the procedure.

Complications were systematically categorised based on their temporal occurrence. Early complications occurring within 24 hours included persistent bleeding at puncture or exit sites, soft tissue swelling, haematoma, cardiac arrhythmias, vascular injuries, cardiac perforation, arteriovenous fistula formation, intimal injury, venous thrombosis, vasovagal reactions, pneumothorax, haemothorax, air embolism, allergic reactions, contrast reactions, persistent pain, anaesthetic complications, catheter kinking, access difficulties, and suture-related occlusion. Intermediate complications occurring between 24 hours and 30 days included catheter tip migration, occlusion, fragmentation, inadvertent removal, connection failures, wound dehiscence, venous thrombosis, extremity swelling, infuscate infiltration, access difficulties, and catheter-related infections. Late complications occurring after 30 days included infections, thrombosis, swelling, tip migration, venous perforation, cardiac perforation, arrhythmias, inadvertent removal, connection failures, catheter fracture, occlusion due to fibrin sheath formation, erosion through vessel wall or skin, infuscate infiltration, and access difficulties.

Follow-up data collection included patient status (alive or dead), cause of death when applicable, date of last follow-up, and duration of follow-up in days, months, or years. Specific outcomes measured included catheter survival, technical success rate, dates of insertion and removal, reason for removal (completion of indication, infection, blockage, fracture, malposition, or other specified reasons), and device survival interval. Infection-related parameters were documented when present, including whether infection was confirmed, organisms grown if any, and infection site (catheter tip, entry site, or blood).

Technical success was strictly defined as successful catheter insertion into the venous system with the tip positioned at the desired location and confirmed functionality for intended use, demonstrated by ability to withdraw blood for sampling and infuse saline without significant resistance [14]. For tunneled haemodialysis catheters in adult patients, adequate blood flow was defined as 300 mL/min or more. Device survival interval was calculated as the total number of catheter days from implantation until removal due to complications or device failure, completion of therapy, or patient death with the device in place [15].

This comprehensive methodology ensured rigorous evaluation of all relevant clinical and technical parameters while maintaining strict adherence to the original data collected during the study period. The analysis was limited to parameters explicitly documented in the case records, without extrapolation or inclusion of additional assumptions beyond the available data. The systematic approach to data collection and analysis provided a robust framework for evaluating outcomes of image-guided CVC insertion in the study population.

STATISTICAL ANALYSIS

The study employed statistical analysis to evaluate the collected data. Variables were presented as frequency with percentage for categorical data and mean with standard deviation or median for continuous variables as appropriate.

RESULTS

The study evaluated 100 consecutive patients who underwent image-guided CVC placement at our tertiary care centre. The analysis revealed several important findings regarding patient demographics, procedural characteristics, and clinical outcomes. The study consisted of 60 male (60%) and 40 female (40%) patients. Age distribution showed a wide range from 2 to 72 years, with the largest proportion of patients in the 21-30 years age group (25 patients). Notably, male patients were most frequently in the 21-30 years range (17 patients), while female patients showed a bimodal distribution with peaks in both 21-30 years (8 patients) and 41-50 years (9 patients). The demographic characteristics of the sample are presented in [Table/Fig-1].

Age group (years)	Male (n=60)	Female (n=40)	Total (N=100)
≤10	1	2	3
11-20	9	5	14
21-30	17	8	25
31-40	9	6	15
41-50	9	9	18
51-60	12	4	16
61-70	2	6	8
71-80	1	0	1

[Table/Fig-1]: Patient demographic characteristics.

The majority of catheter placements (91%) were performed for malignancy-related indications, primarily chemotherapy administration. As depicted in [Table/Fig-2], the most prevalent underlying malignancies were acute leukaemias/lymphomas (25 cases), Non-Hodgkin's lymphoma (17 cases), and Hodgkin's lymphoma (12 cases). Co-morbid conditions were present in 46 patients, with diabetes mellitus (8 cases), hypertension (8 cases), and combined diabetes with hypertension (5 cases) being most frequently documented.

Characteristic	Number of cases (n=100)
Underlying diagnosis	
Malignancies	91
- Acute leukaemias/lymphomas	25
- Non-hodgkin's lymphoma	17
- Hodgkin's lymphoma	12
- Other malignancies	37
Healthy donors	9
Co-morbid conditions	
Diabetes mellitus	8
Hypertension	8
DM+HTN	5
Other co-morbidities	25

[Table/Fig-2]: Clinical indications and co-morbid conditions.
DM-diabetes mellitus HTN-hypertension

The clinical indications and catheter selection patterns revealed significant practice trends, as illustrated in [Table/Fig-3]. Tunneled catheters (Permacath) were the most frequently placed devices (41 cases), followed by PICCs (36 cases). The right internal jugular vein served as the primary access site (61 cases), consistent with current guideline recommendations. Technical success was achieved in all cases (100%), with fluoroscopic confirmation of proper catheter tip position at the cavoatrial junction.

Parameter	Number of cases (n=100)
Catheter type	
Tunneled (Permacath)	41
PICC	36
Non-tunneled	16
Port	6
Central line	1
Access site	
Right internal jugular	61
Basilic vein	36
Femoral vein	3
Technical success	100 (100%)

[Table/Fig-3]: Procedural characteristics.

The study achieved complete follow-up documentation for 97 patients, with three cases lost to follow-up (accounting for the full 100-patient cohort). Comprehensive outcomes are presented in [Table/Fig-4], integrating catheter retention status, complication profiles with microbiological data, and device survival metrics.

Outcome category	Subcategory	Number of cases (N=100)	Additional metrics
Follow-up completion	Completed follow-up	97	-
	Lost to follow-up	3	-
Catheter status	Removed	73	-
	- Therapy completion	64	-
	- Infection-related removal	4	-
	- Mechanical failure removal	3	(2 occlusions, 1 migration)
	- Other reasons	2	-
	Retained at follow-up	24	-
Device survival	Mean duration	-	146 days
	Range	-	6-365 days
	Median	-	135.5 days
Complications	Total infectious	4	-
	- *E. coli*	1	-
	- *Klebsiella pneumoniae*	1	-
	- *Pseudomonas aeruginosa*	1	-
	- Culture-negative	1	-
	Mechanical	3	(as above)
Mortality	Total deaths	7	0 catheter-related

[Table/Fig-4]: Comprehensive follow-up outcomes.

These results demonstrate that image-guided CVC placement achieved excellent technical success with acceptable complication rates in our patient population. The right internal jugular vein emerged as the preferred access site, while tunneled catheters and PICCs were the most commonly utilised devices for intermediate-to-long-term vascular access.

DISCUSSION

The results of this study demonstrate that image-guided CVC placement achieves excellent technical success rates with an acceptable safety profile in a tertiary care setting. Our findings align with contemporary literature while providing specific insights relevant to clinical practice in India. The 100% technical success rate observed in our cohort compares favourably with reported success rates of 92-98% in similar studies utilising ultrasound and fluoroscopic guidance [16,17]. This consistency underscores the reliability of image-guided techniques when performed by experienced interventional radiologists following standardised protocols.

The demographic distribution of present study patients reflects patterns seen in other Indian studies of vascular access, with a male predominance (60%) and broad age representation [18,19]. The high prevalence of malignancy-related indications (91%) mirrors trends observed in oncology centres across India, where central venous access remains essential for chemotherapy administration [1,20]. The relatively young mean age (37 years) of present cohort differs from Western populations, reflecting India's demographic profile and disease burden patterns.

The present study data on catheter type selection provides valuable insights into current Indian practice. The preference for tunneled catheters (41%) and PICCs (36%) corresponds with global trends favouring these devices for intermediate-to-long-term access [21,22]. The 61% utilisation rate of right internal jugular vein access aligns with international guidelines recommending this site for its safety and anatomical advantages [23]. However, in present study, 3% femoral vein access rate appears lower than some Indian reports, possibly reflecting our institution's emphasis on upper body access sites.

The complication rates observed in our study merit careful consideration. The 4% infection rate compares favourably with recent Indian reports ranging from 5-15%, suggesting the aseptic protocols and postinsertion care were effective [24]. The spectrum of infectious organisms (*E. coli, Klebsiella*, *Pseudomonas*) matches antimicrobial resistance patterns documented in Indian ICUs [25,26]. Mechanical complications (2 occlusions, 1 migration) occurred at rates consistent with international benchmarks [27].

The device survival data provides important practical insights. The mean functional duration of 146 days falls within the 120-180 day range reported for tunneled catheters in comparable settings [28,29]. The 64% removal rate for completed therapy suggests appropriate utilisation, while the 24% retention rate at follow-up indicates ongoing clinical need. The absence of catheter-related mortality reinforces the safety of these procedures when performed with image guidance.

Several findings warrant special emphasis in the Indian context. The predominance of right internal jugular access (61%) with low complication rates supports current guideline recommendations, while the 36% basilic vein access for PICCs reflects growing acceptance of this approach [1,30]. The 7% overall complication rate compares favourably with 10-15% rates reported from Indian centres not using routine image guidance [31,32].

These findings have several practical implications for clinicians in similar settings. First, they reinforce the value of establishing dedicated vascular access teams trained in image-guided techniques. Second, they highlight the need for ongoing monitoring of infection rates and antimicrobial resistance patterns. Third, they support the development of institutional protocols for catheter selection based on anticipated duration of need and patient characteristics.

Limitation(s)

The present study has important limitations that should inform interpretation of the results. The single-centre design may limit generalisability, and the retrospective nature introduces potential documentation bias. The absence of standardised protocols for some aspects of catheter maintenance may affect complication rate comparisons. Future prospective studies could incorporate quality-of-life measures and cost-effectiveness analyses to provide more comprehensive evaluation.

CONCLUSION(S)

This study demonstrates that image-guided CVC placement achieves excellent technical success with low complication rates in a tertiary care setting, validating current practice standards while identifying infection prevention as a key area for quality improvement. The findings support the preferential use of ultrasound-guided right internal jugular access and appropriate selection of tunneled catheters or PICCs based on clinical need, providing a reliable framework for safe vascular access in similar healthcare environments. The results underscore the importance of standardised protocols and trained procedural teams in optimising patient outcomes for this essential intervention.

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