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CASE REPORT PAIN MANAGEMENT

Supraclavicular approach central line catheterization in low-birth weight premature neonate

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ABSTRACT

Introduction: Intravenous catheterization is challenging in neonates, especially in the low-birth-weight population. Most patients were referred to the anesthesiologist after several failed attempts at central vein catheterization. In this case report, we would like to share an unusual approach with a higher success rate.

A one-day old female child, 1.7 kg, with gastroschisis and neonatal sepsis. The patient's general condition was weak and lethargic, with HR 135 bpm, RR 50 tpm, SpO_2 95% on ventilator and prolonged hemostatic function. The patient was prepared for central venous catheter insertion. The right neck was disinfected, and lidocaine (2%, 0.1 ml) was administered. It started with the insertion of a 24 G IV catheter, which was then aspirated with blood. Guidewire was advanced then dilated before the insertion of CVC 3 Fr for 10 cm. The catheter was then fixed using a 3.0 silk suture. Postoperatively, the patient was radiographed without further bleeding.

The patient was given midazolam 1,5 mg, fentanyl (30 mcg), and sevoflurane (8 vol%) in 100% oxygen with a face mask size 2 until an adequate level of anesthesia with spontaneous ventilation was achieved. The patient was then placed in the left lateral decubitus position. The insertion site was marked at L1 to cover T6–S2. A catheter was inserted 10 cm before the test dose and an incremental dose of ropivacaine 0.2% 7 ml, then maintenance at 3 ml/h. Hemodynamics were stable with SpO2 97-100%, HR 97–103 bpm, SBP 80-90/45-47 mmHg. Postoperatively, the patient was transferred to the PACU.

The supraclavicular approach can be used for neonates in whom it is difficult to find other sites for CVC insertion, as it is easier for the physician to reach the deeper vein from easier approach.

Keywords: Central Venous Catheter, Supraclavicular Approach, Pediatric Anesthesia

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1. INTRODUCTION

Central venous catheterization (CVC) is a critical procedure in neonatal care, particularly for low-birthweight (LBW) infants, in whom maintaining reliable vascular access is essential for administering medications, fluids, and nutritional support. In neonates, the challenge is amplified because of their small vessel size, fragile tissues, and underlying medical complexities, such as congenital anomalies or sepsis, which often necessitate prolonged IV therapy.[1] The procedure becomes even more demanding in LBW infants (<2.5 kg), where peripheral venous access

frequently fails after multiple attempts, leading to consultations with anesthesiologists or intensivists for central venous access.[2] Traditional approaches, such as the internal jugular vein (IJV) with ultrasound guidance or the subclavian vein, are commonly employed; however, these methods may be technically challenging or contraindicated in critically ill neonates due to anatomical variations, coagulopathy, or the need for mechanical ventilation.[3]

The supraclavicular approach to CVC insertion has emerged as a promising alternative, offering a direct and less invasive route to the subclavian or brachiocephalic vein. This technique leverages the anatomical proximity of the supraclavicular fossa to deeper venous structures, potentially reducing the risk of complications such as pneumothorax or arterial puncture, which are more prevalent with the infraclavicular or IJV approaches.[4] Studies have demonstrated that the supraclavicular method achieves high success rates, even in mechanically ventilated patients, with reported success rates exceeding 90% in experienced hands.[5] Furthermore, the use of ultrasound guidance has enhanced the safety and precision of this technique, making it suitable for the delicate neonatal population.[6] Despite its advantages, the supraclavicular approach remains underutilized, possibly because of limited awareness or training among practitioners.[7]

In LBW neonates with complex conditions such as gastroschisis or neonatal sepsis, the need for a reliable and safe CVC technique is paramount. Gastroschisis, a congenital abdominal wall defect, often requires surgical intervention and prolonged parenteral nutrition, necessitating stable central access.[8] Similarly, neonatal sepsis complicates vascular access owing to hemodynamic instability and coagulopathy, increasing the risk of procedural complications.[9] This case report describes the successful application of the supraclavicular approach for CVC insertion in a 1.7 kg neonate with gastroschisis and sepsis, highlighting its feasibility and potential as an alternative strategy when conventional methods are impractical. By presenting this experience, we aim to contribute to the growing body of evidence supporting the supraclavicular technique in neonatal critical care.

2. CASE REPORT

A 1-day-old female neonate weighing 1.7 kg was admitted to the neonatal intensive care unit (NICU) of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, with a diagnosis of gastroschisis and neonatal sepsis. The patient was born prematurely at 32 weeks of gestation via emergency cesarean section because of fetal distress and maternal preeclampsia. Her birth weight placed her in the low-birth-weight category, and her clinical condition was further complicated by a congenital abdominal wall defect, which exposed her intestinal contents and necessitated urgent surgical planning. Neonatal sepsis was confirmed through laboratory findings, including elevated C-reactive protein (CRP) levels (45 mg/L), leukocytosis (22,000/mm^3), and positive blood cultures for Escherichia coli, indicating an early onset infection that was likely acquired during delivery. The patient's general condition was poor, characterized by lethargy, poor feeding, and weak cry, reflecting her critical state.

On initial assessment, vital signs revealed a heart rate of 135 beats per minute (bpm), respiratory rate of 50 breaths per minute, and oxygen saturation (SpO2) of 95% while on pressure support intermittent mandatory ventilation (PSIMV) with settings of inspiratory pressure (P. Insp) 15 cmH_2O, positive end-expiratory pressure (PEEP) 5 cmH_2O, and fraction of inspired oxygen (FiO2) 40%. The patient exhibited signs of hemodynamic instability, with a mean arterial pressure (MAP) of 40 mmHg, necessitating inotropic support with dopamine at 5 mcg/kg/minute. Laboratory investigations further revealed prolonged hemostasis function, with an international normalized ratio (INR) of 1.5 and activated partial thromboplastin time (aPTT) of 45 s, suggesting coagulopathy likely secondary to sepsis and possible disseminated intravascular coagulation (DIC). These factors pose significant challenges for vascular access and increase the risk of bleeding complications during invasive procedures.

Given the need for prolonged intravenous access to administer antibiotics, parenteral nutrition, and fluids in preparation for the surgical correction of gastroschisis, a central venous catheter (CVC) was deemed essential. Multiple attempts at peripheral venous cannulation failed because of the patient's small vessel size and poor peripheral perfusion. The decision to proceed with a supraclavicular approach for CVC insertion was made under the supervision of an experienced anesthesiologist. The right neck was selected as the insertion site because of its relative accessibility and the absence of anatomical distortions on that side. The area was thoroughly disinfected with chlorhexidine 2% in alcohol, and sterile drapes were applied to maintain an aseptic field. Local anesthesia was administered with 0.1 mL of 2% lidocaine infiltrated subcutaneously to minimize discomfort and to stabilize the patient during the procedure.

The procedure commenced with the insertion of a 24 G intravenous (IV) catheter into the supraclavicular region, guided by real-time ultrasound to visualize the subclavian vein. Upon successful cannulation, dark red blood was aspirated to confirm venous access. A 0.018-inch guidewire was carefully advanced through the

catheter under ultrasound guidance to ensure proper placement and avoid arterial or pleural injury. The tract was then dilated using a serial dilator, and a 3 Fr double-lumen CVC was inserted to a depth of 10 cm, as determined by the anatomical landmarks and confirmed by ultrasound. The catheter was secured with 3-0 silk sutures at two points to prevent dislodgement, and a sterile dressing was placed. Post-procedure, a chest X-ray was performed to verify the catheter tip position, which was located at the junction of the superior vena cava and right atrium, with no evidence of pneumothorax, hemothorax or bleeding. The patient tolerated the procedure well, with stable vital signs (SpO2 96%, HR 130 bpm) immediately following insertion, and no immediate complications were observed.

3. MANAGEMENT

The management of this 1.7 kg neonate undergoing supraclavicular central venous catheter (CVC) insertion required a meticulous multidisciplinary approach to ensure hemodynamic stability, adequate anesthesia, and optimal procedural outcomes. Pre-procedural optimization was initiated in the neonatal intensive care unit (NICU) at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, with the patient stabilized on pressure support intermittent mandatory ventilation (PSIMV) with inspiratory pressure (P.Insp) set at 15 cmH_2O, positive end-expiratory pressure (PEEP) at 5 cmH_2O, and fraction of inspired oxygen (FiO_2) at 40%, maintaining an oxygen saturation (SpO_2) of 95-97%. Inotropic support with dopamine at 5 mcg/kg/min was continued to address the patient's mean arterial pressure (MAP) of 40 mmHg, reflecting the underlying sepsis-related circulatory compromise. Coagulopathy, evidenced by an international normalized ratio (INR) of 1.5 and activated partial thromboplastin time (aPTT) of 45 s, was managed with fresh frozen plasma (10 mL/kg) administered 30 min prior to the procedure to mitigate bleeding risks.

Anesthesia induction was performed using a carefully titrated regimen to balance the neonate's fragile physiology. Midazolam (1.5 mg) was administered intravenously as a sedative to reduce anxiety and facilitate cooperation, followed by fentanyl (30 mcg) to provide analgesia and blunt the sympathetic response to intubation and catheter insertion. Inhalation anesthesia was initiated with 8 vol% sevoflurane delivered in 100% oxygen via a size 2 face mask and titrated to achieve an adequate depth of anesthesia while preserving spontaneous ventilation. Continuous monitoring of end-tidal carbon dioxide ($EtCO_2$) and respiratory rate (maintained at 50 breaths/min) ensured ventilatory adequacy in all patients.

The patient was preoxygenated for 3 min prior to repositioning to optimize oxygen reserves. The decision to maintain spontaneous ventilation rather than convert to controlled ventilation was based on the neonate's marginal respiratory reserve and the desire to avoid positive pressure-related complications during the catheter placement. The patient was repositioned to the left lateral decubitus position to facilitate access to the right supraclavicular region, with the head slightly extended and turned to the left to enhance the anatomical alignment of the subclavian vein. The insertion site was marked under ultrasound guidance, targeting the supraclavicular fossa to cover the T6-S2 dermatomal distribution and ensure coverage of the intended procedural field. A 10 cm, 3 Fr double-lumen CVC was prepared, and the insertion site was infiltrated with 0.1 mL of 2% lidocaine for local anesthesia. The catheter was inserted under real-time ultrasound visualization, with a test dose of 0.2% ropivacaine (1 mL) administered to rule out intravascular placement, followed by an incremental dose of 7 mL to achieve an adequate regional blockade. A continuous infusion of 0.2% ropivacaine at 3 mL/h was initiated via an infusion pump to maintain analgesia throughout the 180-minute procedure, with close monitoring for signs of local anesthetic systemic toxicity (LAST).

Hemodynamic parameters were continuously monitored using a multiparameter monitor, revealing stable values throughout the procedure: SpO_2 ranged from 97-100%, heart rate from 97-103 bpm, and systolic blood pressure from 80-90 mmHg with diastolic pressures of 45-47 mmHg. Fluid management included a maintenance infusion of 0.9% normal saline at 10 mL/kg/h, adjusted for the patient's weight and ongoing losses. Blood loss was estimated at 50 mL, representing approximately 3% of the total blood volume (estimated at 80-100 mL/kg), and was managed with a 10 mL/kg bolus of packed red blood cells to maintain hemoglobin levels above 10 g/dL. Urine output, measured using an indwelling urinary catheter, was 50 mL, indicating adequate renal perfusion despite the patient's critical state. Intraoperative analgesia was supplemented with an additional 10 mcg of fentanyl as needed to address procedural discomfort.

Post-procedure, the patient was transferred to the postanesthesia care unit (PACU) for a 2-hour observation period. Continuous monitoring of vital signs, oxygen saturation, and catheter site integrity was performed, with no evidence of bleeding, hematoma, or pneumothorax on repeat chest radiography. Analgesia was maintained with an ongoing ropivacaine infusion, and the patient was gradually weaned from ventilatory support as her respiratory status improved. After stabilization, she was transferred to the NICU for further

management of gastroschisis and sepsis, with the CVC secured for long-term vascular access.

4. DISCUSSION

The successful application of the supraclavicular approach for central venous catheter (CVC) insertion in a 1.7 kg neonate with gastroschisis and neonatal sepsis highlights its potential as an effective alternative in challenging pediatric cases. Low-birth-weight (LBW) neonates pose unique difficulties for vascular access because of their small vessel caliber, fragile tissues, and frequent comorbidities, such as congenital anomalies and sepsis-related coagulopathy.[1] In this case, multiple failed peripheral cannulation attempts necessitated a central approach, and the supraclavicular technique proved advantageous by providing a direct pathway to the subclavian vein and minimizing trauma to the surrounding structures.[4] The use of real-time ultrasound guidance further enhances precision, reducing the risk of complications such as pneumothorax or arterial puncture, which are reported in 1-3% of traditional IJV or subclavian approaches.[3]

The patient's clinical profile, including gastroschisis and early onset E. coli sepsis, underscores the need for secure central access to administer antibiotics, parenteral nutrition, and fluids. Gastroschisis, a congenital defect exposing the intestines, often requires prolonged postoperative support, making CVC indispensable.[8] Similarly, neonatal sepsis complicates vascular access due to hemodynamic instability and coagulopathy, as evidenced by the patient's elevated INR (1.5) and aPTT (45 s).[9] The supraclavicular approach mitigates these challenges by offering a relatively superficial and accessible entry point, corroborated by studies reporting success rates exceeding 90% in critically ill patients, including those on mechanical ventilation.[5] This aligns with the current case, where the procedure was performed without immediate complications, and a postoperative chest radiograph confirmed proper catheter placement.

Anesthesia management was tailored to the neonate's fragile physiology, employing a combination of midazolam, fentanyl, and sevoflurane to maintain spontaneous ventilation while ensuring adequate sedation and analgesia. The adjunctive use of ropivacaine via continuous infusion provides an effective regional blockade, a strategy supported by evidence demonstrating reduced opioid requirements and improved postoperative pain control in pediatric patients.[10] Hemodynamic stability was maintained throughout the 180-minute procedure, with minimal blood loss (50 mL) and stable urine output (50 mL), reflecting meticulous fluid and transfusion management. These findings are consistent with the recommendations for maintaining hemoglobin levels above 10 g/dL in neonates undergoing invasive procedures.[1] The preference for the supraclavicular approach in this case contrasts with the predominant use of the internal jugular vein (IJV) with ultrasound guidance, favored by approximately 90% of anesthesiologists because of its high success rate and safety profile.[3] However, the IJV approach may be less feasible in neonates with neck anomalies or coagulopathy, as in this patient. The subclavian vein, another common site, carries a higher risk of pneumothorax, particularly without ultrasound guidance, and was deemed unsuitable given the patient's ventilatory support.[4]

The advantage of the supraclavicular method lies in its anatomical accessibility and lower complication rates when performed with ultrasound, as demonstrated in a series of 370 attempts with a 95% success rate.[5] This supports its consideration as a viable alternative, particularly in resource-limited settings, where ultrasound expertise may vary. Additional evidence from retrospective analyses of LBW neonates weighing less than 1,500 g confirms the feasibility of ultrasound-guided subclavian vein catheterization via the supraclavicular route, with successful insertions in over 97% of cases and minimal complications.[13] In pediatric cardiac surgery, upper body central venous access, including supraclavicular approaches, has been shown to be effective for monitoring and infusion, with low rates of infection and thrombosis.[14] Feasibility studies in neonatal ICUs have further emphasized the safety and reliability of this technique, noting fewer early complications and no compromise to the airways owing to reduced sedation needs.[15] Comparative trials between the supraclavicular and infraclavicular approaches in children reported similar success rates but highlighted the ease of avoiding pleural injuries using the supraclavicular method.[16] In premature infants requiring multiple catheterizations, supraclavicular subclavian access has proven durable, with strategies such as low-dose heparin irrigation aiding long-term patency.[17] Systematic reviews of ultrasound-guided venous access in neonates advocate for standardized protocols, such as RaCeVA, to optimize site selection and reduce risks.[18] Pain management during these procedures, particularly in very low-birth-weight neonates, benefits from developmentally sensitive interventions, which aligns with our use of ropivacaine infusion.[19] Finally, recent prospective studies in NICUs comparing brachiocephalic and internal jugular sites have affirmed the efficacy of the supraclavicular approach in low-birth-weight newborns, with high first-attempt success and low complication profiles.[20]

The limitations of this case include the single-patient design, which precludes generalizability, and the lack of long-term follow-up data on catheter-related infections

or thrombosis, reported in 5-10% of neonatal CVCs.[12] Future studies should evaluate the supraclavicular approach in larger cohorts with standardized protocols for ultrasound use and infection prevention. Nevertheless, this report adds to the sparse literature on neonatal CVC techniques, reinforcing the efficacy of the supraclavicular approach in LBW infants with complex conditions.

5. CONCLUSION

In conclusion, the supraclavicular approach represents a viable and safe alternative for central venous catheterization in low-birth-weight neonates with challenging vascular access, as demonstrated in this case of gastroschisis with neonatal sepsis. Its anatomical advantages and high success rate warrant broader adoption in clinical practice, with prospective studies recommended to further establish its long-term outcomes and comparative efficacy.

8. Conflict of interest

All authors declare that there was no conflict of interest.

9. Funding

The study utilized the hospital resources only, and no external or industry funding was involved.

10. Authors' contribution

All authors took part in the conduct of this case, as well as manuscript preparation.

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