started on pulse methylprednisolone (10 to 30 mg/kg/day), sicker children received higher doses, usually resulting in clinical improvement by the next 2 to 3 days.

There was no mortality during the first wave, whereas there were three deaths during the second wave; one due to refractory macrophage activation syndrome (MAS) and two with late referral, who succumbed to severe myocarditis and refractory hypotension.

The antigenic shift of the virus led to differences in severity and outcome between the two COVID waves. This difference was also evident amongst the MIS-C patients with change in clinical presentations, the Delta variant leading to a disease of increased severity and poorer outcome.

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Neonatologist-Performed Ultrasound-Guided Internal Jugular Vein Cannulation

We retrieved data of ultrasound-guided neonatal internal jugular vein (IJV) cannulations done between November, 2020 and March, 2021. Of the 33 ultrasound-guided IJV cannulation in neonates, 32 were successful with overall success rate of 97%. Median (IQR) number of attempts per insertion was 2 (1,3.5). There were no major complications observed during the insertion of the catheter. In one instance, inadvertent carotid artery puncture was encountered, without significant bleeding.

Key words: *Central line, Percutaneous, Simulation, Training*.

Trial registration: CTRI/2021/07/034944

Traditionally, cannulation of internal jugular vein (IJV) is performed by a 'blind' technique based on anatomical landmarks [1]. This technique; however, has a high failure rate and may be associated with several complications such as inadvertent carotid artery puncture, pneumothorax or hemothorax, and formation of hematoma, particularly in young infants [1,2]. Ultrasound (USG)-guided IJV cannulation is a standard technique in pediatric population and is reported to have reduced risk of cannulation failure as compared to conventional approach [3]. Literature on neonatal USG-guided IJV cannulation is limited, and has been mainly described by anesthesiologists or pediatric surgeons [2,4-6].

We describe the success rate and complications of neonatologist-performed USG-guided IJV cannulation

Fig. 1 Chicken breast simulator and its ultrasound image. Left side shows one chicken breast with dye filled tube. It is covered with another breast on top and wrapped with a plastic cover. Right side shows ultrasound image of model casting an acoustic shadow resembling a large vein.

from a tertiary care unit. The unit is a 32-bedded level 3B accredited neonatal intensive care unit. The unit has more than 1200 admissions per year, of which approximately 60% are extramural neonates; most being referred in critical condition such as hypoxic respiratory failure or shock, without any reliable venous access. In this retrospective study, demographic and clinical details of neonates who underwent IJV cannulation between November, 2020 and March, 2021 were retrieved. Outcome measures were success of cannulation, number of attempts per cannulation, catheter dwell time, and complications such as carotid artery puncture, pneumothorax, hematoma formation, cardiac tamponade, arrhythmia and central line-associated blood stream infection. The study was approved by institutional ethics committee and registered with the Clinical Trial Registry of India. The neonatologists acquired necessary training and expertise by first observing the cannulation performed by interventional radiologists, and then practicing puncturing at artificial targets in phantom models. This was followed by training on a simulation model, prepared by placing a rubber tubing filled with fluid, tunnelled in between chicken breast pieces, tightly wrapped in a plastic cover (**Fig. 1**) [7].

All IJV cannulations were performed by one of the two neonatologists, using Sonosite M Turbo machine with 13-6 MHz linear probe. Informed consent was obtained from the parents before the procedure. Neonates were positioned in the Trendelenburg position by placing a shoulder roll and head was tilted to the opposite side. We used short-axis, out-of-plane method, in which, USG probe was kept in a perpendicular manner, approximately at the base of Sedilot triangle to visualize IJV and surrounding structures in cross section. Internal jugular vein was differentiated from carotid artery based on its ellipsoid shape, larger size, presence of compressibility and absence of pulsatility. Venepuncture was performed under real time USG visualization with a 22-gauge cannula, introduced just behind the mid-point of the probe, at an angle 45-60% and directing it towards the ipsilateral nipple. Non-dominant hand was used to hold the probe and dominant hand was used for needle puncture. Successful puncture was ascertained by free flow of blood through the cannula, following which a guide-wire of calibre 0.46 mm was introduced through it. Subsequently, cannula was removed, while keeping guide wire in place and a catheter of 22-gauge, 4 cm length (leaderflex, Vygon) was threaded over the guide wire using Seldinger technique. Following this, guide-wire was removed and line was secured, after ensuring free flow of blood. Radiograph was done to confirm tip position and to evaluate for complications such as pneumothorax or hemothorax. Number of attempts and complications were routinely recorded on the patient's case record. Maximum five attempts were made, following which the procedure was abandoned. Cardiac tamponade was identified by sudden onset hypotension, muffled heart sounds and enlarged cardiac silhouette on radiograph. Cardiac arrhythmia was defined as any change in the normal sequence of heart rhythms during or after catheterization and confirmed on electrocardiogram. Central line-associated blood stream infection was defined as positive blood culture not related to an infection at another site, when the jugular line was in place at the time of or within 48 hours before the onset of infection.

During the study period, a total of 33 IJV cannulations were performed on 29 neonates. Of these, 32 (97%) were successful. Median (IQR) number of attempts per insertion was 2 (1, 3.5). All IJV cannulation were performed on extra-mural neonates, who had no access for umbilical or peripherally inserted central venous catheters. Majority (68.2%) of cannulations were performed on right IJV. The mean (SD) birth weight and gestation of neonates were 2405 (860) g and 35.17 (4.2) weeks, respectively. Nineteen neonates were mechanically ventilated at the time of line insertion. Cumulative success rate with first, second and third attempt was 39%, 51.5% and 75.8%, respec-tively. Median (IQR) catheter dwell time was 13.5 (7.0, 17.5) days. There were no major complications observed during insertion of catheter. In one neonate, who was extremely preterm, inadvertent carotid artery puncture occurred without significant bleeding. Attempt to cannulate was unsuccessful in another neonate, who was born at term gestation. In this patient, cannulation was attempted without use of sedation, as there was no IV access available prior to procedure. Central line associated blood stream infection was reported in three cases. All except three catheters were removed once not required. One catheter was removed on day 8 of insertion due to local extravasation, while two were removed on day 15 and day 22 due to catheter occlusion.

Literature regarding feasibility and success rate of neonatologist-performed USG-guided IJV insertion is limited. Goldstein, et al. [5] reported feasibility of USG-guided IJV cannulations in 20 neonates, which were performed by pediatric surgeons or anesthesiologists [5]. Cannulations were performed successfully in all neonates without any complication related to the procedure. Similarly, Tapia, et al. [2], in a case series of USG-guided IJV cannulation performed on neonates by pediatric surgeons, observed a high success rate (94%) with median (IQR) number of attempts 2 (1,8). Authors reported procedure related complications in none of the

neonates [2]. Oh C, et al. [4] reported serious complication in one out of 12 IJV cannulations performed by pediatric surgeons, in the form of hemoericardium [4].

USG-guided cannulation of peripheral veins in neonates is technically challenging as these vessels have a narrow lumen and small diameter. We performed IJV cannulation in extramural neonates, in whom the umbilical and peripheral veins were exhausted. Internal jugular vein was preferred over femoral veins as it is a larger and more easily accessible vein with a diameter that exceeds femoral vein by at least 50% [8]. We used single tube, chicken breast simulation model for training. Further improvement of this model can be done by inserting another fluid-filled tube to simulate carotid artery and therefore enhancing skills to avoid carotid artery puncture.

To the best of our knowledge, this is the first feasibility report of neonatologist-performed USG-guided IJV cannulation. Our findings suggest that neonatologist-performed USG-guided IJV cannulation is feasible, with success and complication rates comparable to those reported with other interventional operators [2,4-6]. Before contemplating the procedure on neonates, intensivists should acquire adequate skills by undergoing systematic training on simulation models.

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