Spectrum of Invasive Critical Procedures Performed by Clinical Fellows in Pediatric Intensive Care (PICU) of a developing Country

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Conflict of Interest*:* None

Funding*:* None

Abstract: 250 words

Text: 1900 words

References: 21

Table: 1

Figure: 1

ABSTRACT:

OBJECTIVE: The objective of this study is to describe the frequency of invasive critical procedures (ICPs) performed by pediatric critical care medicine (PCCM) fellows during their training period.

DESIGN: Retrospective study.

SETTING: Multidisciplinary, closed 6-bed pediatric intensive care unit (PICU) staffed by four pediatric critical care physicians.

MATERIAL AND METHODS: We reviewed the electronic medical record and logbook of each fellows from January 2018 to December 2019. Two most commonly performed Invasive Critical Procedures (ICPs) included in this study were Endotracheal intubation and US-Guided Central Venous Catheter (USG-CVC) insertion. Demographic data and details of ICPs performed were collected on structured data collection sheet. Primary outcome was the frequency of ICPs performed by clinical fellows during the training period and their success rate.

RESULTS: Of total 1080, 352 Invasive Critical Procedures (ICPs) were performed on 560 (51.8%) patients by four PCCM fellows during two years period. Only two most commonly performed procedures i.e. ET-intubation and UG-CVC insertion were included in this study. These ICPs comprised of Endotracheal tube placement (52.85%, n=186) and Ultrasound Guided Central Venous Line insertion (47.15%, n=166). 64.4% of patients was under five-years, 56% were male and 72% were admitted with cardio-respiratory failure. The frequency of endotracheal intubation

was 23 / fellow / year and USG-CVC insertion was 21 / fellow / year and the success rate was >90%.

CONCLUSION: Our clinical fellows performed adequate numbers of endotracheal intubation and USG-CVC insertion to achieve competency of procedural skills during their training period.

KEY WORDS: Pediatric Critical Care Fellow, Invasive Critical Procedure, PICU, Endotracheal intubation, Ultrasound-Guided central venous catheter insertion.

Introduction:

Pediatric Critical Care Medicine is a well-established discipline of Pediatrics in developed countries and is in a very early stage in developing countries such as Pakistan. Respiratory failure and shock of various etiologies are the most common reasons for admission in pediatric intensive care unit of developing countries (1). Lack of prompt recognition and delay in implementation of appropriate interventions increases the morbidity and mortality in these critically ill or injured children in the first 24 hours of admission (2,3). Pediatric Critical Care Medicine Fellowship is recently recognized as a second fellowship in Pediatrics by College of Physicians and Surgeons Pakistan (CPSP), the national governing body of post-graduate education. The acquisition of medical knowledge and technical skills are necessary to achieve competency in pediatric critical care medicine (4). The medical knowledge can be acquired by bedside teaching rounds, dedicated lectures and studying text books and journals and free online access like "OPEN Pediatrics". The trainees learned procedural skills gradually over a period with personal interest. The gaining competencies in procedural skills for trainees is essential like airway management, vascular access and point of care ultra-sonography (5). The importance of safe and secure endotracheal intubation and central venous catheter insertion has become life-saving procedures in the management of children with respiratory failure and shock. Acquiring skills and competency to perform invasive critical procedures (ICPs) is essential to deliver the highest level of care and ensuring patient safety(6). There is no minimum number of ICPs required for competency in procedural skills for PCCM fellows defined in PCCM fellowship. However, a recent study demonstrated that PCCM fellows are getting limited opportunity for critical care procedures in PICU during their fellowship

training(6). The objective of this study is to assess the frequency of performing invasive critical procedures (ET-intubation and UG-CVC insertion) by pediatric critical care fellows during their training period.

Methods: We reviewed electronic record from PICU data base of all children (1mo-14yrs) admitted in Pediatric Intensive Care Unit (PICU) of The Indus Hospital (TIH) Karachi who received invasive critical procedures by clinical fellows from January 2018 to December 2019. This data was reaffirmed from log book of pediatric critical care fellows. The Indus Hospital (TIH) is a large, Non-Government Organization (NGO), tertiary-care, post-graduate training center with a large pediatric oncology unit. Pediatric Critical Care Unit (PICU) of TIH is 6-beded, level-III, and closed multi-disciplinary unit. The team comprised of PICU consultant, clinical fellows and pediatric residents. Nurse-patient ratio is 1:1. The PICU is equipped with advance technology like blood gas machine, point-of-care ultrasound machine, HFOV as well as CRRT machine. The pediatric critical care team provides clinical service to PICU and perform pediatric procedural sedation and analgesia to a large volume of pediatric oncology patients. The PCCM team is supported by many other subspecialties such as pediatric surgery, pediatric nephrology, pediatric cardiology, pediatric infectious disease and pediatric oncology team. Inclusion criteria for study consists of all children who required invasive critical procedures (ICPs) in their management during their stay in PICU. The clinical fellowship in Pediatric Critical Care Medicine was initiated in 2018 with induction of two fellows per year. Currently, we have four clinical fellows in our PICU. We defined the Invasive Critical Procedures (ICPs) as “all invasive procedures performed on critically ill or injured children in their management in PICU”. These ICPs included endotracheal intubation, Ultrasound-Guided central venous catheter insertion, arterial line

insertion, pigtail catheter insertion. However we considered two most commonly performed procedures in this study i.e. Endotracheal intubation and UG-CVC insertion. All ICPs were performed with all aseptic precautions according to standard guidelines. We have checklist for each ICP in our PICU. After each ICP, the documentation (including type, success, and immediate complications) was noted on physician-procedure note as well as nurse documentation. Each PCCM fellow was also provided with a log book to make entries after each clinical procedure and academic activities like topic presentation, journal club and mortality presentation. The *primary outcome* was frequency of ICPs performed by clinical fellows during study period. The demographic variables (age, gender), admitting diagnosis, and procedural details (including type, indication and procedure-related complications was collected on structured data collection sheet. Descriptive statistics was applied on SPSS v.22. The ethical approval was obtained from Institutional ethical committee (IRD_IRB_2019_10_010).

Results:

Of total 1080 patients, 352 ICPs were performed on 560 children (51.85%) by four clinical fellows during the study period. We included only two most commonly performed procedures in our study i.e. endotracheal tube placement (52.84%, n=186) and Ultrasound Guided Central Venous Catheter insertion (47.15%, n=166). Approximately two third 64.44% (n=696) of the study population was under the age of 5 years and 51.38 % were male. Almost three-fourth of study population 72% (n=782) were admitted with cardiopulmonary failure and shock states. The frequency of endotracheal intubation, US-Guided CVC insertion, were 52.85% (n=186) and 47.15% (n=166), respectively (Table 1). The frequency of arterial line insertion and pigtail catheter insertion by fellows was very low and not included in the study. The overall success rate was more

than 90%. On an average each fellow performed approximately 23 endotracheal intubation and 21 UG-CVC insertion per year. The frequency of each procedure per fellows was shown in Figure 1.

Discussion: Our PCCM fellows performed 352 ICPs in 560 critically ill children during study period. Sixty-seven percent of program directors of PCCM fellowship in United states agreed that ten (n=10) successful CVC insertion should be required to make them competent during training in a survey of program directors suggested an agreement (7). Ishizuka *et al* reported that 90% success rate was achieved after a mean of twenty-six (n=26) endotracheal intubation from a large training center of PCCM fellowship of a tertiary-care pediatric academic institution (8). All of our fellows meet these numbers during their training period. However, Engron *et al* evaluated the frequency of ICPs performed by PCCM fellows during the training period and found declining in the rate of CVC and arterial catheter insertion trends over last ten years period(6). The rate of endotracheal intubation was not changed for PCCM fellows in this cohort. Our fellows had adequate opportunity for endotracheal intubation and CVC insertion. Like Engron *et al*, our PCCM fellows had less opportunity for arterial catheter insertion(6). Few pediatric emergency medicine reports also showed the low rate of critical procedures in large pediatric academic hospitals (9,10). Nevertheless, there is a shift of paradigm in the care of critically ill patients from an approach of very aggressive, invasive, expensive and high rates of complications to a more cautious, vigilant, *non-invasive,* and careful for associated risks. Advances in modern medicine have introduced sophisticated and reliable noninvasive monitoring techniques in acute care settings like emergency room and intensive care units(11). The various forms of non-invasive ventilation decrease the need of tracheal intubation, while on the other hand oxygenation assessment by new technology of pulse oximetry as well as end tidal CO_2 ($EtCO_2$) monitoring

significantly decrease the rate of arterial line insertion for blood gas measurement and use of vasoactive agents through a good peripheral line in the early phase decreases the need of CVC insertion (12,13).

There is an increasing evidence of simulation-based medical education in last two decades in the literature (14). Several reports are available with significant positive impact on clinical outcome from different disciplines of medicine, including high-risk specialties like training in PCCM(15–18).

It is not known that what minimum numbers required for ICPs for PCCM fellows to achieve competency and provide safe and effective patient care. However, our PCCM fellows are very frequently engaged in conducting a large number of pediatric critical care workshops on manikins for pediatric residents in different institutions. In our curriculum, four to six procedures as an assistant, followed by 15 procedures under supervision and 20 procedures performed with distant supervision independently by each fellow. We required that each fellow performed forty US-Guided CVC insertions as well as forty endotracheal intubations during their training to become competent in our institutional fellowship program. We used Work Based Assessment Tool (WBAT) in our institution. We use Direct Observation of Procedural Skills (DOPS) as a formative assessment tool for assessing competencies in ICPs as published in the literature(19). This DOPS will help Entrustable Professional Activity (EPA) which is the modern way to assess the competency-based education(20).

There were several limitations in our study. The major one was retrospective, single center and small sample size. We were unable to record number of attempts and complications related to procedure. We did not calculate the ICPs per 1000 admissions. However, it was only very few in numbers, we did not include the procedure done by residents or consultants. Recently, the taskforce

of PCCM, a sub-board of American Board of Pediatric trying to create a comprehensive document to establish necessary knowledge and skills in PCCM to serve as a vital tool in guiding education and practice assessment (21). This document may serve as a guideline for them in creating education and training programs of PCCM.

Conclusion: We found that our PCCM fellows performed adequate numbers of endotracheal intubation and US-Guided CVC insertion to achieve competency in procedural skills during their training period. Simulation-based education can fill this gap and improve the education and skills of the trainees.

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Table 1: Invasive Critical Procedures Performed by PCCM Fellows during Two Years

List of Procedures Total Procedures = 461			TOTAL No. (%)	Procedures Per Fellow Per Year
Procedures	**2018 (#)**	**2019 (#)**	**ALL # (%)**	
ET-Intubation	**86**	**100**	**186 (52.85%)**	**23**
USG-CVC insertion	**63**	**103**	**166 (47.15%)**	**21**
TOTAL	**149**	**203**	**352 (100%)**	**44**

Figure # 1: Graphic Appearance of Procedures by PCCM Fellows