Introduction

Advances in paediatrics especially in the field of intensive care have dramatically improved the prognosis for the critically ill children. Numerous conditions that were previously fatal are now treatable, and many children who previously would have sustained a permanent disability now recover completely. The current evidence suggests that the sickest subgroup of critically ill children are less likely to die if treated in paediatric intensive care unit (PICU) in a tertiary care hospital. Advances in the care of the critically ill child have not come cheaply, and there are problems in terms of costs, resources, technical problems, and stress on staff, family and child. To some, intensive care appears over-invasive, unreasonably expensive, frequently ineffective, and a drain on the limited health service resources. So, for the optimal management of the critically ill children, the paediatrician and the anaesthetist dealing with the children should be familiar with critical complications of all childhood diseases, and be aware how invasive intensive care can significantly improve the prognosis.

Overseas History of Paediatric Intensive Care

The development of Paediatric Critical Care followed the development of adult and neonatal intensive care. Florence Nightingale established the concept of Critical Care in 1863, who grouped postoperative patients into a common area, which reported significant reduction in the postoperative morbidity and mortality. During the epidemic of poliomyelitis in Copenhagen, it was recognised that children had higher mortality than adults in these poliomyelitis cases; so, the Paediatric Intensive Care was established in 1950s in Sweden and Stockholm. In United States the first PICU was established in 1967 with the help of Mr. Downes. The Society of Critical Care medicine was established in 1968, and the Paediatric section of the SCCM was established in 1984. Then slowly the paediatric critical care developed in other parts of the world, like Europe and Australia.

History of paediatric critical care in India

Though there were many centres taking care of the critically ill children, these children were treated in adult intensive care unit. Though one accepts the principle that the common denominator is not the age of the patient or which service he or she originates from, but rather the round the clock availability of paediatric oriented intensive care specialists. There are two specific objections to combine adults and children. The first is that children come in all different size and shapes and are not small people but different people. The second objection is that of potential of psychological trauma to a small child in a busy unit managing adults and children. So, with that in the mind the first organised paediatric Intensive Care Unit was established in 1991 at Kanchi Kamakoti Childs Trust Hospital, with seven beds with separate team of doctors and nurses, with the paediatric anaesthesiologist as the in charge of the Unit. The first organised paediatric Advanced Life Support course recognised by the American Heart Association, American Academy of Pediatrics and the Indian Academy of Paediatrics was conducted at Chennai by Dr. N. Janakiraman, Past Chairman and Director, Division of paediatric critical care, Cook county Children’s hospital, Chicago, USA. Thereafter, the PALS course is being conducted regularly in India, which has created lot of awareness and enthusiasm among the paediatricians in the concept ‘Critically ill children can be saved’. In 1997 the intensive care group of Indian Academy of Paediatrics was formed. The first national congress of paediatric critical care was held at Nagpur lead by Dr. Deopujari in 1998. In 1999, the paediatric section of the Indian Society of Critical care medicine was established. The Journal, Indian Journal of Critical Care medicine, is a peer reviewed journal which has articles published regularly on subjects related to paediatric critical care. The paediatric Intensive Care group of Indian Academy of Paediatrics publishes regularly the half yearly newsletter ‘THE INTENSIVIST’. The Paediatric section of Indian Society of Critical care Medicine has given some guidelines for the organisation of paediatric critical care in India.

Personnel

In maintaining a paediatric intensive care unit one must understand that it is doctors and nurses who care for the patients and not the machines. In United States, in establishing PICU, 80% of the investment is for the personnel and 20% for the rest like equipments. But, in India it is the other way round. To take up the profession of paediatric critical care, they must have personalities different from the most other medical fields. The aspect of critical care is a ‘complex dynamic world’. These aspects are that it is event driven dynamic and tightly complex,
uncertain and risky. The qualities of the Intensivist should have strong commitment, possess knowledge, good judgement, adaptability, must have clinical skills, with good communication skills and leadership qualities.

Problems faced in India
The children with life threatening illness are admitted to various hospitals providing different levels of care. There of two major categories of care, one is private and the other is public. There are conflicting roles of physicians. The consumers are poorly informed. Lack of proper insurance coverage makes middle class family unable to afford the treatment in the paediatric intensive care. The training for exclusive paediatric critical care is limited in our country. There are a few centres in Chennai, Delhi, Chandigarh, and Bombay, trying to offer some formal training in the Paediatric intensive care. But with all these limitations in our country, the branch of paediatric intensive care is growing slowly and steadily.

Factors for the development of PICU in India
There are many factors, which led to the development of paediatric critical care in India. One of the important factors is the growth of super specialities like paediatric cardiac surgeries and paediatric neurosurgeries and many complicated procedures being done by paediatric surgeons. It was observed that the children had higher mortality. Critical care is more and more equipment oriented and the liberalisation of import of equipments by the Government of India helped very much in the development of PICU. We have better trained people in the field of paediatric intensive care due to many conferences and workshops. The concept “Most of the sick babies are ventilated, most of the sick babies die, that is most of the ventilated babies die so why should we ventilate the babies” has gone. The nurses and the medical personnel have better knowledge of mechanical ventilation. Each developed PICU in India is showing better results year after year. The introduction of PALS course in India by Dr.N.Janakiraman in 1991 is one of important landmarks for the development of Paediatric Intensive Care in India.

Misconceptions about the PICU in India
1. In poor large country like India, the encouragement of paediatric critical care is a misdirected effort.
2. Basic primary health care is lacking and ordinary hospitals facilities in most parts of the country are inadequate is there need for PICU?
3. The tendency to use an intensive care unit as the last halt or ‘stopping station’
4. Most of the sick babies are ventilated, most of the sick babies die, so most of the ventilated babies die.
5. The difference between intensive care now and ten years ago is that we can keep seeing children alive longer, but still they die.

So do we need a PICU?
The answer for the above is unquestionably yes?
1. Even if a small percentage of the people can afford and these children can be saved, it is our duty to save the children whatever the cost may be. The motto of the paediatric intensive care is ‘No child should knock in vain’
2. When an eighty-year-old man with myocardial infarction can be saved, why can’t 4-year-old child with Dengue Shock Syndrome saved, where the question of probability of survival comes.
3. There is definite evidence from the overseas experience and our own experience that the death of child yester years become a rarity these days. We are able to save many children who otherwise would have died for want of acute paediatric care.
4. General paediatrics at present, and in the next century will be limited only to vaccinations, viral fever and PUO as immunisation has wiped off most of the infectious diseases, while ORS(Oral Rehydration Solutions) has wiped off the admissions due to diarrhoea. So, now days, there are more percentage of critically ill children getting admitted in the hospital.

Early Recognition of the critically ill child
Early recognition of the critically ill child, prompt resuscitation and thorough stabilisation of those require transfer will improve outcome provided they are accompanied by appropriate experienced personnel using suitable equipment. The first step to become a critical care practioner is to understand critical illness for that one must know the normal values of different age group.

<table>
<thead>
<tr>
<th>Age</th>
<th>Heart rate</th>
<th>Blood pressure</th>
<th>Respiratory rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>100-180</td>
<td>85/50</td>
<td>30-80</td>
</tr>
<tr>
<td>6 months</td>
<td>120-160</td>
<td>90/53</td>
<td>30-60</td>
</tr>
<tr>
<td>1 year</td>
<td>90-140</td>
<td>91/54</td>
<td>20-40</td>
</tr>
<tr>
<td>2 years</td>
<td>80-140</td>
<td>91/56</td>
<td>20-30</td>
</tr>
<tr>
<td>6 years</td>
<td>75-100</td>
<td>96/57</td>
<td>20-25</td>
</tr>
<tr>
<td>10 years</td>
<td>60-90</td>
<td>102/62</td>
<td>17-22</td>
</tr>
<tr>
<td>12 years</td>
<td>55-90</td>
<td>107/64</td>
<td>17-22</td>
</tr>
<tr>
<td>16 years</td>
<td>50-90</td>
<td>117/67</td>
<td>15-20</td>
</tr>
</tbody>
</table>
Cardiac arrest in infants and children is rarely a sudden event. It is usually preceded by progressive deterioration in respiratory and circulatory function. So impending cardiac arrest may be averted by early recognition of respiratory failure, circulatory failure and neurological failure.

**Potential respiratory failure**

Infants and young children have less respiratory reserve than older children or young adults, and many patients admitted to the PICU have either a primary respiratory disorder or a respiratory component to their disease. Respiratory failure is the commonest cause of cardiac arrest in children. It may result from upper or lower airway disease. Tachypnoea, recession, use of accessory muscles, grunting are all signs of increased work of breathing. Inspiratory stridor is a sign of upper airway obstruction while wheezing denotes lower airway disease. The onset of fatigue, or coincident neurological impairment, may diminish these important signs and produce a false impression of well being.

**Assessment of adequacy of breathing**

*Work of breathing*
- Recession
- Respiratory rate
- Inspiratory or Expiratory noises
- Grunting
- Accessory muscle use
- Flaring of the nostrils

*Effectiveness of breathing*
- Breath sounds
- Chest expansion
- Abdominal excursion

*Effects of inadequate respiration*
- Heart rate
- Skin colour
- Mental Status

**Potential circulatory failure**

The second principal cause of cardiac arrest in children is circulatory failure due to fluid loss or maldistribution. Circulatory failure (shock) is characterised by inadequate perfusion of organs and tissues. Shock is traditionally classified as hypovolemic, distributive, cardiogenic, obstructive or dissociative. Hypovolemic shock is the commonest cause of shock in children, with sepsis second. The two important things everyone must keep in mind in recognition of shock in children. One is that the journey from late shock to cardiac arrest will be brief. The second one is that since most of the children have excellent compensatory mechanisms for hypovolemia, making early recognition of shock more difficult than adults. In hypovolemic shock there is increased heart rate to maintain stroke volume. Bradycardia in a shocked child is in response to hypoxia and acidosis and is a preterminal event. The blood pressure is maintained in children with shock for long time and hypotension is a late sign in children. Pallor, cool extremities and weak thready pulses are other early indications of shock. In early septic shock there may be an initial high output state resulting in a warm periphery and bounding peripheral pulses. Slow capillary refill is evidence of reduced skin perfusion. The core/peripheral temperature gradient of more than 2 degree and reduced urine output are other early signs of shock.

**Rapid assessment of the adequacy of circulation**

*Cardiovascular status*
- Heart Rate
- Pulse volume
- Capillary refill
- Blood pressure

*Effects on other organs*
- Respiratory rate and character
- Skin appearance and temperature
- Mental status
- Urinary output

**Potential neurological failure**

Mental status forms the other sign of early shock that is often overlooked. Infants may be irritable but drowsy with a weak cry and hypotonia. An important sign of reduced cerebral perfusion in the infant is failure to focus on the parent’s face. Conscious level assessment is made simple with AVPU scale. A paediatric adaptation of glasgow coma scale may be more appropriate in cases of trauma.
Cardio Pulmonary Resuscitation in children

A respiratory or cardiac arrest in infants and children is an acute, life-threatening event requiring immediate intervention. Cardiopulmonary resuscitation is the restoration of automatic and effective breathing and circulation. There are two stages of intervention in CPR.

1. Basic Life Support: The restoration of effective ventilation and circulation using non-invasive methods. That is, breathing expired air into the lungs without mechanical devices and using closed cardiac compression techniques.

Who needs paediatric critical care?

1. Any airway intervention
2. Ventilation or assisted respiration
3. Cardiopulmonary resuscitation
4. Arrhythmia which fails to respond to first line therapy
5. After cardiac surgery
6. Postoperative patient with multiple drains requiring hourly fluid replacement
7. Possibility of progressive deterioration like recurrent apnoeas, airway obstruction
8. Needing inotropes
9. Central Nervous system depression sufficient to compromise the airway protective reflex/respiratory drive or potential to progress
10. Uncontrolled shock needing repeated volume and/or inotropes
11. Diabetic ketoacidosis
12. Tracheostomy children till formation of the track.

Assessment of Conscious level

A Alert
V Response to voice
P Response to pain
U Unresponsive

Paediatric adaptation of the Glasgow Coma Scale (age < 4 years):

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>EYES</td>
<td></td>
</tr>
<tr>
<td>Open spontaneously</td>
<td>4</td>
</tr>
<tr>
<td>React to speech</td>
<td>3</td>
</tr>
<tr>
<td>React to pain</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

BEST MOTOR RESPONSE

Spontaneous or obeys verbal command | 6 |
Localises pain | 5 |
Withdraws with pain | 4 |
Abnormal extension to pain | 2 |
No response | 1 |

BEST VERBAL RESPONSE

Smiles, oriented to sounds | 6 |
Consolable, inappropriate | 4 |
Inconsolable, moaning | 3 |
Inconsolable, irritable | 2 |
No response | 1 |

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Mechanical ventilation in children

Appreciation of the therapeutics of mechanical ventilation requires an implicit understanding of the respiratory physiology and ICU technology. Despite the variety of ventilators and ventilation technology the fundamental physical chemistry and physiology of oxygen and carbon dioxide are unchanged, so at one level one can still expect the novice to handle all devices appropriately. The choice of mode of ventilation is decided on basis of age, diagnosis, available respiratory physiological information, significance of cardiovascular and haemodynamic implications of IPPV and the ventilator capabilities. Once the patient is attached to the ventilator, adequacy of ventilation is immediately assessed clinically through observation of chest movement, colour, perfusion and auscultation of the chest. A minimum standard monitoring for typical, acutely ventilated patients include continuous pulse oxymetry, ECG monitoring, an alarm that detects failure of cycling (circuit disruption), an alarm that detects airway occlusion. For neonates there is historical preference of continuous flow, pressure limited, time cycled ventilators.

Newer technologies in the mechanical ventilation used in children

Prone positioning

In acute lung injury a gradient in regional compliance develops favouring non-dependent lung. In addition, due to an increase in lung mass, there is an accentuation of the normal gradient in pleural pressure, which increases as one approaches dependent lung. The increased dorsal lung recruitment and ventilation, rather than a significant redistribution of regional blood flow, improves oxygenation and ventilation /perfusion matching, and reduces shunt in patients with lung injury in several uncontrolled studies: The improvement in compliance that occurs in the prone position may allow reductions in FiO₂ and PEEP and augment drainage of secretions from dependent lung. Safety concerns, including accidental extubation and catheter removal, hemodynamic instability and pressure necrosis can limit the application of prone position.

Pressure Regulated Volume Control (PRVC) ventilation (Volume guaranteed)

PRVC ventilation is a mode of ventilation now available in newer ventilators. This method delivers a controlled tidal volume and minute volume in a pressure limited manner using the lowest possible pressure, which is constant during the inspiratory phase. The gas flow is decelerated and pressure and flow constantly vary, breath by breath, in order to achieve the pre-set tidal volume at minimum peak inspiratory pressure. It is particularly useful in patient ventilated where there are rapid changes in lung compliance and airway resistance, for instance when surfactant and bronchodilators are used. The ventilator tests the first breath at 5 cms of water above PEEP and calculates the pressure volume ratio. The inspiratory pressure changes breath by breath until the preset volume is reached at a maximum of 5 cms of water below the set pressure limit. At this stage the measured tidal volume corresponds to the preset value and the pressure remains constant. If the measured tidal volume increases above the preset level, inspiratory pressure is reduced until the set tidal volume is reached. The method appears to be useful in improving respiratory mechanics and gas exchange, in reducing the barotraumas caused by PIP, in limiting oxygen toxicity due to the possibility of using reduced FiO₂ to maintain adequate gas exchange as compared to mechanical ventilation. The use of decelerating flows favours opening of closed areas of the lung and laminar flow, which allows the reduction of PEEP levels in case of haemodynamic implications. It appears also beneficial when drugs such as surfactant, bronchodilators, nitric oxide, etc., which bring about a rapid change in compliance and airway resistance, are used.

Volume support ventilation

Volume Support Ventilation is a new means of assisting spontaneous breathing which avoid the disadvantages deriving from Pressure Support Ventilation. The ventilator, breath by breath, adapts the inspiratory pressure support to the changes in the mechanical properties of the lung and the thorax in order to ensure that the lowest possible pressure is used to deliver the pre-set tidal volume that remain constant. The inspiratory pressure is constant and the flow is decelerating. In cases of apnoea ventilation automatically switches to PRVC. The initial values of tidal and minute volume should be set, as should all parameters to be used to PRVC in the presence of apnoea ventilation.
Death of a child in ICU

Death of a child in the intensive care unit is particularly stressful for both family members and staff. Everyone involved can experience a sense of failure or helplessness through his or her inability to prevent the child's death. Caring for the dying child and her family is both a privilege and a challenge. The staffs involved participate in the construction of a memory, which will remain with the family. The management of the death will have significant implications for the parent's adjustment to life without the child. Parents whose children are admitted to intensive care often feel that this is where their critically ill child will be cured, because it is 'Centre of Excellence'. So death of a child is a huge shock for the parents. So many parents are psychologically unprepared, often disbelieving and denying the situation, and experiencing severe feeling of guilt, optimum communication is essential, as is providing every opportunity for contact with the child. Their involvement and consultation is both crucial and empowering in helping their work through their reactions to death. The parents will be emotionally vulnerable, may be hostile and intensely angry toward caring for them and their child. Although difficult, it is important that staff support them through these feelings. Informing parents of the terminal nature of their child's illness or even of their death is one of the hardest tasks facing the professional. The person imparting such news should be known and trusted by the parents, and posses good communication skills. So the key components of 'ideal' care for bereaved parents include skills in breathing bad news, the ability to communicate honest, accurate information, demonstration of compassion, available for consultation, provision of support and grief counselling. When these components are optimised, pathological grief reaction is less likely.

Unit design

It should be a separate unit from the neonatal and adult ICU dedicated to children. Unit design should take into consideration future adaptability and expansion and must maximize the resource of space, time, equipment, communication and personnel in a most affordable way. No traffic to other departments should pass through the unit. Unit should be located near a lift with easy access to the emergency department and operation theatre, laboratory and radiology department. Doctor's duty Room as well as Intensivist's Duty Room / Office should be close to the PICU, with intercom facility. Other facilities nearby should include a staff area with locker cabinets, a family waiting area to provide for two persons per admitted patient with bathroom shower and telephone facility. PICU size is not known but about but 6-10 beds is ideal. ICUs less than 4 beds risk inefficiency, and ICUs greater than 16 beds may be difficult to manage, if not properly divided. In general for total pediatric ward beds up to 25, a PICU of 6 - 8 beds is ideal. Additional beds may be required if specialized surgery such as Heart Surgery; Neurosurgery and Trauma Surgery cases are routinely done. Room layout should allow actual visualization of all patients from central station. ICU cubicles should have sliding glass doors to allow full visibility. Patient area in open ICU should be 150 to 200 sq.ft. in a cubicle. The minimum area should be 200 to 250 sq.ft., with at least one wash basin for two beds. However, one for each bed is preferred. At least one, preferably two rooms should have an isolation capability, with an area of 250 sq.ft. with an Ante Room (separate area at least 20 sq.ft for hand washing and donning mask and gown) and have separate ventilation. Area around the bed should allow enough space for performing routine ICU procedures such as central line insertion, chest tube placement, as well as for easy access for portable X-ray machine, portable UltraSound, ECG and EEG machines. An easy access to the head end of the patient for emergency airway management is a must on all beds. Wall and ceilings should be constructed of materials with high sound absorption capabilities. Wall oxygen outlets (two), air outlet (one), two suction outlets, at least ten electrical outlets per bed are recommended for various equipments. In rooms windows are important to prevent a sense of isolation, adequate lighting, child friendly wall paper/paintings with soothing colours and curtains are desirable. Unit should be centrally airconditioned and should have central heating for temperature control. It should have an uninterrupted power supply by means of backup power sources such as invertors and generators in accordance with load of various equipments. Beds should have head end and foot end maneuverability as well as air/water mattress facility to prevent bed sores. All beds must have a railing to prevent accidental fall of the child. Each bed should have an emergency alarm button to activate code in case of a cardiac arrest or other emergencies so additional help can be mobilized. An intercom at each bed is desirable. A cart at the bedside is important to hold personal belongings and required patient items. Crash cart with emergency drugs and portable monitor/defibrillator should be readily accessible. Zones should be provided for medication preparation and cabinets should be available for the storage of medications and supplies. A receptionist area is ideal to control visitation, so that all visitors must go by this area before entering. This area should be monitored by Security.

To conclude paediatric critical care is care that aids and improves child survival. It is doctors and nurses who care for the sick children and not the machines. We should take comfort in the fact that there is no substitute for...
human ingenuity, endeavour and resources. Motivation and dedication towards providing patient care is the most important part in the development of paediatric critical care in India. Though it is a difficult task to organize a paediatric critical care unit please remember the quote “Journey of thousand miles starts with a single step”.

Motto of critical care - “Primum Non Nocere” – First of all, do no harm

References
Care Neonatal Society of Bosnia and Herzegovina Pediatric Section of the Polish Society of Anaesthesiology and Intensive Therapy

Applies for Individuals only. The Journal of Pediatric Intensive Care is an English multidisciplinary peer-reviewed international journal publishing articles in the field of pediatric intensive care.

Download Paediatric Intensive Care apk 1.0 for Android. Paediatric Intensive Care Guidelines.

The description of Paediatric Intensive Care. The first edition of the booklet was written by Frank Shann, Rob Henning and Lara Shekerdemian with contributions from other medical staff at the RCH PICU, including Warwick Butt (ECMO, Filtration), James Tibballs (Envenomation), and Mike South. Many parts of this booklet were developed in collaboration with other departments at the Royal Children’s Hospital, or adapted from material produced by other departments.

Update on: 2018-01-03. Requires Android: Android 4.0+ (Ice Cream Sandwich, API 14). Signature: ae6112ba737c329312f1e547823b0a083c9b610d.