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The Indian Journal of Emergency Pediatrics (ISSN 0975 - 3869) is dedicated to the care of the ill or injured child. The journal presents must-have, practical information dedicated specifically to pediatric and adolescent emergencies. Sections in the journal include clinical articles, case reviews, pediatric update, clinical issues, and drug update. The journal provides peer-reviewed original articles on the clinical, professional and educational aspects of emergency pediatrics.

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Editorial

Doing enough..... Fast enough.....

Health care in India is different with its structure, resources, culture and priorities. Provision of care for paediatric emergencies is driven by parental concern and commitment of the emergency team. The question is whether we are doing enough, fast enough. Emergency teams feel strengthened through newer technologies but have we strengthened the pre-hospital care for such emergencies? It cannot be denied that the path forward in health care is newer innovations in technology and health care delivery. The newer ones, remain technologies to be used only in specific cases and only in situations where there are adequate resources. Health care is economy and reconciling the market and the health needs is tightrope walking. Orienting the upcoming generation of medical students, health workers towards a timely and appropriate pre-emergency care is mandatory. The learning needs can be prioritised and broken down to short modules, primarily skill-based, to fit with the local picture. The work of Indian Snakebite Research Initiative and the Train the Trainer proposals put in place by the National Snakebite Management Task Force of Government of India are exemplary models of action and skill oriented modules (ref.1,2). Our Journal shall provide a platform to all paediatricians for exchanging, sharing their perceptions and providing "skills checklist" for relevant paediatric emergencies.

Priority to diagnostic tests versus medicine is a continuing dilemma. Unfortunately this is common everywhere. The reliance on tests instead of observation and patient interaction is endemic. Partly this is due to the structure of medicine itself. Everywhere senior doctors have little contact with patients as juniors prevail. When juniors need help they phone the senior usually in consulting chamber or in a meeting and ask for help. The senior does not see the patient apart from ward rounds. The reliance on distant help and lack of contact is structurally built into medicine. Diagnostic tests are another manifestation of distant help given remotely that tells you what to do. Most of what doctors should do is observational and yet ordering tests is easier. I will always remember being taken to a victim who was being assessed with diagnostic tests and noticing she had blown pupils!!! The child had been in the hospital for 6 hours and nobody else had noticed! Tests also reduce numbers of patients that can be treated as they reduce overall budget!! In developing countries number of patients treated is everything. The western model that everybody should receive the best possible is fundamentally flawed as we are finding to our cost. Whether we like it or not it is always about resources and the more basic the tool the better. There is an urgent need to refine the existing diagnostic and therapeutic procedures rather than invest in expensive ones. We always pen down good proposals for Best Practice Guidelines. These proposals are always good but they simply remain an output not a programme. What is needed is a PRACTICAL programme, implementable, monitor-able and with the results assessed. Otherwise it is just a CV booster and children still die.

Mahadevan S.
Editor-in-Chief

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1. Mahadevan S .Jacobsen I., National Snakebite Management Protocol (India), 2008(Shortened version) . Indian Journal of Emergency Pediatrics. 2009:1 :63-84
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The Path forward

In a country of 1.16 billion population of whom 31.5% are children, the no of paediatricians required to justify the cause of child health would be a huge number which at present is neither feasible nor practical. In such a situation, empowering the community physician (who often is the first and only contact to majority of the children) with the knowledge and necessary skills to manage common childhood emergencies would make a huge difference to the health of children. Thus, in an attempt to improve the morbidity and mortality in children at the community level (rural as well as urban) at the community level, a high-level meeting was held on 15th November, 2010 at the India International centre, New Delhi. The meeting was chaired by national and international experts in the field of Emergency Medicine and Intensive Care including Dr J S Surpure (USA), Dr Sunit Singhi (PGIMER, Chandigarh) and Dr Suresh Gupta (SGRH, New Delhi). The meeting was attended by members of the Core Group of Paediatric Emergency Medicine from all over the country. As an editor of this journal, I had the privilege of attending the meeting.

The agenda of the meeting was "Engineering the Training Program for Health Care Providers" and was organised by the Society for Trauma and Emergency Paediatrics (STEP) and Institute of Child Health, Sir Ganga Ram Hospital, New Delhi.

The main objectives of the meeting were

* To start a course on the management of common childhood emergencies for the community practitioners.
* To identify the target group faculty for delivering the course and the group which will undergo the course?
* To design a resource material for the course entitled "Children's Medical Emergencies - a Compendium for Community Practitioners" and decide the contents and pattern of the same;
* To decide the contents and duration of the course, and the timeline for the first course
* To elaborate on the logistics and funding for future courses.

After much discussion and deliberation by the group members, the following points were agreed upon:

* The first such course on common childhood emergencies for the community practitioners would be held at Chennai on 28th January, 2010 at the 'National Assembly on Paediatric Emergency Medicine' conference.
* It would be a 4 hour workshop and the target group would be Registered Medical Practitioners (RMP). A total of 40 participants would be trained.
* The registration would be free for the participants.
* The course contents would be in lecture and video format accompanied by skill stations wherever applicable.
* A proposal for funding of future courses by the Ministry of Health to be prepared and presented at the secretarial level
* The frequency at which the course would be held to be decided after test running the first course; training of trainers for the course to be held at regular intervals to maintain quality of the course.

The core group then identified 12 most relevant common childhood emergency topics that are of importance to the community physicians. Each faculty was allotted one of the 12 topics to prepare. The deadline for preparation of the resource material including lectures was fixed at 30th Nov. The format of presentation of most of the topics was decided upon. It was decided that depending on the feedback from the participants and other core group members the contents of the resource material would be finalised.

Initiation of such an ambitious project such as this would not have been possible without the dedication of the team members who took their valuable time out to come together for a noble cause like this. We wish the group good luck in their endeavour and hope to see a healthy future for the children of our country.

Jhuma Sankar
Executive Editor

FAOPS 2010

16th Congress of
The Federation of Asia and Oceania Perinatal Societies
14th-17th December, 2010 Hotel The Ashok, New Delhi, India

"Bridging Gaps in Maternal-Neonatal Health"

Registration Fees

Upto 30th Sep 2010
India & SAARC Countries
Rs.8000
International
USD 500
Senior Citizens, PG Students & Residents*
Rs. 4000 or USD 250

1st Oct 2010 - December 2010
India & SAARC Countries
Rs. 9000
International
USD 550
Senior Citizens, PG Students & Residents*
Rs. 4000 or USD 250

On Spot
India & SAARC Countries
Rs.10000
International
USD 600
Senior Citizens, PG Students & Residents*
Rs. 4000 or USD 250

Workshop
India & SAARC Countries
Rs.500
International
USD 35

Accompanying Person
India & SAARC Countries
Rs. 5000
International
USD 400

LAST DATE
30th Oct, 2010
FOR ABSTRACT SUBMISSION

HIGHLIGHTS OF THE PROGRAMME

Tuesday, December 14, 2010 Workshops / Mini Courses Conference Day 1

9.00 am – 10.00 am	Registration
10.00 am – 5.00 pm	8 mini workshops in Neonatology & Perinatal medicine.

*Each delegate can choose any two workshops – one in the morning session and one in the afternoon session. Details of workshop given in the registration form
6.00 pm onwards – Inaugural Dinner

Wednesday, December 15, 2010 Conference Day 2

8.00 am – 9.00 am	Morning Session: 1. New NRP Guideline 2. Retinopathy Of Prematurity 3. Early VS Delayed Cord Clamping
9.00 am – 11.00 am	Plenary Sessions: Meeting Challenge of IUGR
11.00 am – 11.30 noon	Keynote address: Ethics in Perinatal Medicine
12.00 noon – 1.45 pm	Concurrent Symposia: 1.Neonatal Infections 2. Controversies in Newborn care 3. Controversies in Perinatal Care 4. Symposium on Caesarean section
2.45 pm – 4.15 pm	Awards & Free Paper Sessions
7.00 pm Onwards	FACULTY DINNER

Thursday, December 16, 2010 Conference Day 3

8.00 am – 9.00 am	Morning session: 1. Perinatal Database Management 2. Beyond NICU care 3. Difficult to ventilate neonates
9.00 am – 11.00 am	Plenary Sessions: Perinatal Asphyxia / Global epidemic of HIE
11.30 am – 12.00 noon	Keynote address: Perinatal Steroids
12.00 noon – 1.45 pm	4 Concurrent Symposia: 1. Kernicterus 2. Emerging /affordable Technology in Perinatal care 3. Evidence based practices 4. Problems of isoimmunization
2.00 pm – 3.30 pm	Free Paper Presentations
6.00 pm Onwards	Cultural Evening & Gala Dinner

Friday, December 17, 2010 Conference Day 4

9.00 am – 11.00 am	Bridging Gaps in Maternal Neonatal Health – To meet the challenge of MDG 4 & 5
11.30 am – 1.00 pm	4 Concurrent Sessions: 1. Community Interventions in reducing NMR in South Asia 2. Scientific Symposia in Neonatology on Late Preterms 3. Community Interventions in reducing MMR in South Asia 4. Nutrition
1.00 pm – 1.30 pm	VALEDICTORY

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Protecting the pediatric lung in emergency room: Practical measures

Giuseppe A Marraro, MD

ABSTRACT

Baro- and volutrauma, surfactant deficiency, oxygen toxicity, and the development of atelectasis have been investigated in depth in recent years in order to protect the lung during ventilation and reduce the risk of ventilation induced lung injury (vili). Protective lung strategies have been implemented in a variety of clinical contexts that require transferring to emergency room., Pressure ventilation can control the risk of elevated airway pressure (pip) but does not assure less damage to the lung. Tidal volumeappears to be more damaging for the lung as it can favour lung over-distension or create hypoventilation, both harmful clinical conditions for the lung. Peep plays an important role in avoiding the closure and re-opening of the terminal bronchioles implicated in lung damage, and in maintaining the alveolus continuously open. Peep improves oxygenation (increase of functional residual capacity – frc) and can reduce the need for high fio_2 (less oxygen toxicity). Maintaining the lung distended for 8-15 seconds at the end of inspiration appears to be helpful in lung recruitment strategy and in the resolution of atelectasis., Ventilation of a child in emergency needs skill and competence that must be acquired in ordinary routine and not in critical care.

Key words: emergency, emergency room, lung protective strategy, ventilation, baro-volutrauma, oxygen toxicity, atelectasis, infant, children3

INTRODUCTION

Air flows into the lung from the external environment as a result of the decrease in intra-thoracic pressure and leaves the lung passively on recoil of chest. No positive pressure is applied to the airways during the inspiratory phase to favor the entry of air towards the lungs. After respiratory exchange has taken place in the alveolus the air exits the lung passively.

The quantity of air required per minute is regulated by the organism in relation to the quantity of oxygen to be taken in and to the elimination of co_2. While it is necessary to increase functional residual capacity (opening up of a greater number of alveoli) for the diffusion of oxygen, the elimination of co_2 from inside the lung is achieved by the alternation of the respiratory act (entry, or inspiration, and exit, or expiration, of air to the lung).

In normal conditions the organism is able to increase current volume by means of one or more respiratory acts for the purposes of increasing gas exchange and preventing the formation of atelectasis.

Ventilating artificially, the introduction of a quantity of air into the lung (tidal volume) is defined *a priori* and is pushed into the airways by the application of positive pressure, known as insufflation pressure. Positive pressure during inspiration must be sufficient to overcome the resistance that the air meets in the airways before reaching the alveolus.

Respiratory rate is defined also *a priori* on the basis, initially, of the patient's theoretical physiological values and of his/her age, and subsequently with reference to the values recorded for pao_2 and $paco_2$ in the blood, or arterial blood gas (ABG).

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Introducing the current volume of air required for gas exchange into the airways, this volume follows the path of least resistance offered by the airways and by lung compliance. This explains why the better ventilating areas are more easily and more completely filled with air in comparison to the less ventilating areas. As a result, certain areas, particularly those which are dependent, may close against ventilation and become atelectasic.

To avoid atelectasis and maintain pao_2 and $paco_2$ in normal range gas exchange, large tidal volume and low respiratory rate strategy has been used in the past.

Various undesired effects have been considered in relation to the application of mechanical ventilation starting from when it was first used [1,2]. In particular, lung barotrauma has been connected with the pressure used to introduce tidal volume, and the appearance of emphysema and lung rupture (pneumothorax) were evident clinical indicators of the undesired effects of mechanical ventilation. This led to the introduction and development of controlled positive pressure ventilation, both manual and artificial, as a protective ventilatory mode for the lung.

The evaluation of harm incurred by lung tissue during the application of artificial ventilation has been systematically evaluated and ample clinical experience is available as well as an extensive consensus view regarding ventilator-induced lung injury (VILI) and ventilation associated lung injury (VALI), whether in normal or pathologic lung in anesthesia and intensive care. In large studies the injury sustained at birth by newborns during resuscitation following manual ventilation even if of short duration, is clearly implicated in the pathogenesis of bronchopulmonary dysplasia (BPD) [3,4].

It is a logical consequence that the evidence from ventilation support and early lung damage may be extended to apply to infants and children and from anesthesia and intensive care to the emergency room.

VENTILATION MODES IN EMERGENCY

A patient's spontaneous breathing can be partially assisted or totally controlled. In the first case the child starts the inspiratory phase and supplementary tidal volume is insufflated to obtain suitable ventilated tidal volume. In this condition the work of breathing is shared between the operator and the patient. In the second case, the operator supports the patient's respiration and work of breathing totally.

In emergency room in general two devices are used for ventilation: auto-inflating bag and flow-inflating bag (*figure 1*). Facial and nasal masks, laryngeal mask and endotracheal tube are used as interfaces to connect the child to the inflating bag. Intubation is a more invasive method compared to mask ventilation but protects the airway from aspiration, enables correct lung ventilation avoiding gastric distension and favors bronchosuction [5].

1. Auto-inflating bag

This device incorporates an adapter to connect a mask, an endotracheal or tracheostomy tube, an auto-inflating bag, a pressure-relief, non-rebreathing valve, and a port for gas inflow. The volume of the bag varies from about 0.250 ml to 1 liter for pediatric application. The device appears to be safest for avoiding lung overexpansion but in some circumstances it is difficult to deliver a volume suitable for pediatric patients. The unidirectional valve does not allow pressure over 30 to 35 cm of h_2o, which can be ineffective in cases of need of higher pressure to expand the lung (e.g. Low compliance), in the presence of endotracheal tubes of small diameter (higher resistance) and in severe lung pathology.

The main advantages of this system are

1. Does not need a gas source to inflate;
2. Remains inflated at all times irrespective of oxygen or gas source;
3. Pressure release valve to protect from high peak inspiratory pressure;
4. Easy to use.

Figure 1: Auto-inflating bag (above) and flow-inflating bag (below)

Several disadvantages are connected to this system. The self-inflating bag gives no indication of leaks and will inflate even without adequate seal and no flow return from the lungs. The automatic re-expansion of self-inflating bag may falsely reassure even though a large proportion of delivered breath may lost through a leak around the mask. It does not provide peep and cannot deliver a sustained prolonged inflation (one second or longer) useful to alveolar recruitment and cannot be used to deliver 100% free flow oxygen. It requires attachment of an oxygen reservoir to deliver 100% oxygen.

2. Flow-inflating bags

These devices are continuous-flow, semi-open breathing systems and non-rebreathing depends on the location of the fresh gas inflow, overflow valves, rate of fresh gas flow, respiratory rate, tidal volume and whether ventilation is spontaneous or controlled. Most devices employ the mapleson d circuit with the fresh gas source attached just distal to the point of connection to the patient. They are more frequently used in anesthesia.

During expiration, the patient's exhaled tidal volume mixes with fresh gas flowing into the system and accumulates in the tubing and bag. With sufficiently high fresh gas flow, alveolar gas is washed to the overflow valve and eliminated from the circuit. They may apply high volume inflation according to volume of ventilated gas (generally oxygen) and presence of a pressure-regulating valve.

The gas and valve are regulated manually by the operator. The bag can be fitted with a manometer and a pressure pop-off. If the valve is not adequately regulated, a large volume of gas can reach the lung, over-distending it. A protective strategy suggests using low flow and a fully open valve, increasing the flow progressively and regulating the opening of the valve in relation to the efficacy of insufflation.

The main advantages of this system are

1. It can produce a peak inspiratory pressure (PIP) of any level suitable to reopen the lung;

2. It can be used to deliver prolonged inflation in recruiting lung maneuvers;
3. It can provide peep by controlling the rate of gas escape at the outlet from the bag and maintaining a positive pressure in the system during expiration. Maintaining the bag distended at the end of exhalation (PEEP) can be of benefit in different obstructive and low compliance lung pathologies (e.g. RDS, ARDS, bronchiolitis and asthma).

OTHER ADVANTAGES ARE

1. Possibility of delivering 100% oxygen at all times;
2. Easy to determine the adequacy of seal and reduce gas leakage;
3. Possibility of evaluating the "stiffness" of lung, compliance and resistance;
4. Can be used to deliver 100% free flow oxygen.

The main disadvantages of this system compared to the self-inflating bag are that a source of compressed gas is required and the absence of safety pop-off valve. Its correct use requires more experience and training.

RECENT ACQUISITIONS ON LUNG DAMAGE FROM VENTILATION

Over the past 10 years greater attention has been paid to damage associated with baro- and volutrauma, with type ii alveolar cells and to the surfactant produced by them, with side effects of high levels of fio_2, and the development of atelectasis. Direct damage connected with artificial ventilation is still under-investigated, despite the fact that all the knowledge to transfer what shows up in intensive care into the emergency room is available [6, 7].

1. Structural lung damage directly connected to ventilation support
2. Internal homeostasis alteration with reduction of cilia mobility and stiffening of secretions;
3. Surfactant impairment from high FIO_2, cold and dry gases, and ventilation modes;
4. Baro-volutrauma creating emphysema up to pneumothorax;
5. Side effects and complications
6. Primary or secondary aspiration due to lack of protective control of airway in cases of predisposing pathology, seizures and coma in brain trauma;
7. Damage from oxygen toxicity;
8. Damage to larynx, trachea, main bronchi and esophagus in performing traumatic intubation (e.g. Use of unsuitable endotracheal tubes and laryngeal mask).

Other factors that contribute to, or aggravate, lung injury include preexisting lung damage and/or inflammation, high oxygen concentration, reduction in secretion removal, use of inadequately humidified and warmed gases, level of blood flow, and the local production of systemic release of inflammatory mediators (biotrauma).

The state of the art with respect to main acquisitions is as follows

1. Not only the pressure used to introduce the air into the lung creates barotrauma but the quantity of air introduced for each breath (tidal volume) also plays an important role in lung damage;
2. More damage is created ventilating dis-homogeneous and/or uni- plurilobar lung patology. In these cases higher opening pressures must be applied to re-ventilate closed areas. These higher pressures are damaging to the normo-ventilating lung regions;
3. Repeated alveolar collapse and re-opening (shearer forces) due to low end-expiratory pressure: application of peep reduces shearer forces and enables continuous maintenance and recruitment of a greater number of alveoli to ventilation;
4. Atelectasis can be present or may develop rapidly in sedated, paralyzed and

mechanically ventilated children (8). Non ventilating lung areas can be reopened using recruitment maneuvers including peep application and maintaining lung insufflation at end of inspiration for seconds (8 - 12??) (redistribution of air in the alveoli and recruitment);

5. High fio_2, especially if oxygen is used cold and dry, modifies lung homeostasis, creates stiffening secretions and toxic free radicals that play an important role in the genesis of biotrauma [(9)].

This knowledge, preferentially acquired in intensive care, in ventilation of premature newborns, in neonatal resuscitation and in anesthesia leads to considerations and advice which prove extremely important in lung protective strategies of ventilation support in emergency room.

PRACTICAL MEASURES

ASPIRATION

Two essential maneuvers are suggested to protect from aspiration: 1. Lateral positioning of the child and 2. Direct visualization of upper and lower airway before starting manual ventilation in case of suspected or confirmed aspiration.

Aspiration may occur before and after mask and bag ventilation. The passage of air into the stomach in case of incorrect ventilation predisposes to gastro-esophageal reflux and promotes the passage of regurgitated material from the stomach into the pharynx, from where it can easily pass into the main airways. Laryngeal mask ventilation does not avoid the risk of aspiration and its positioning can stimulate vomiting in case of active swallowing reflex. Tracheal intubation is the ideal protective maneuver for avoiding the risk of aspiration and removing aspired material by bronchosuction [(10,12)].

Lateral positioning

One side lateral decubitus is a protective posture applied when it is necessary to protect lower airways from the risk of aspiration and from the obstruction of upper airways due to obstacles to pharynx and larynx. The position favors spontaneous elimination of matter from the mouth and the nose and allows improvement in ventilation. It is advisable in all comatose patients, in patients with insufficient muscle tone of the neck and in those awakening from narcosis.

Airway inspection

Before proceeding with insufflation of the lung it is necessary to ascertain that the airways are open and free of material that could pass the trachea. Airway inspection must be performed in cases of suspected aspiration, in coma and/or seizures. In the event of certainty of aspiration, if the patient is in apnea, proceed with intubation and broncho-aspiration before starting ventilation, in order to remove aspirated material rapidly from the trachea and bronchi and prevent the risk of it spreading to the whole lung.

A recent report[(13)] demonstrated the possibility of selective or total lung broncholavage with saline plus surfactant supplementation during or after lavage, in cases of aspiration. The benefits of such an approach are: the removal of material obstructing the airways, the limitation of the diffusion of the pathology to the controlateral lung, the recruitment of lung areas to ventilation through mechanical airway clearance, resolution of possible atelectasis and an improved stability of the small airways and of the terminal bronchiole in cases in which surfactant is used during lavage.

Saline lavage is not suggested because the saline dilutes the material and favors alveolar absorption. Saline bal, moreover, removes surfactant and exposes alveoli and terminal bronchiole to collapse [(14,15)].

BAROTRAUMA

The term "barotrauma" refers to pressure-related injury induced by large transpulmonary pressure and appears clinically as pneumothorax, pneumomediastinum, or pulmonary interstitial emphysema. A number of studies have documented an association between the

incidence of barotrauma and high peak airway pressure (PAP).

Minor lung damage could occur and often does not show up even on x-ray or ct scan. Therefore, light lung damage may not be immediately visualized but can have a negative influence on the evolution of treatment as well as the final outcome.

The correlation between PAP and barotrauma can occur at extremely low levels of pap and a complete absence of barotrauma despite very high levels of PAP has been demonstrated. Physiologically, lung distension is minimized if plateau airway pressure (PPLAT) is kept reasonably low, arguing that a pressure limited strategy should be as good as a volume limited strategy.

Advantages and disadvantages in the use of auto- and flow-inflating systems have been previously described in prevention of lung damage created by high peak inspiratory pressure (PIP).

VOLUTRAUMA

The incidence of barotrauma has been reported to correlate not only with pap, but also with tidal volume (i.e. Volutrauma instead of barotrauma)[16]. A large-scale clinically controlled study[17] confirmed alveolar over-distension rather than high proximal airway pressures as the primary determinant for lung injury, combined with shear stress evoked by repeated alveolar collapse and re-opening due to low end-expiratory volumes. Lung over-distension appears to be the fundamental mechanism underlying ventilation induced lung injury (VILI) and ventilation associated lung injury (VALI)[18]. Lung over-distension appears to be a culprit also in increased alveolar-capillary permeability.

Low tidal volume strategy is suggested as protective ventilation. Hypoventilation deriving from a reduction in tidal volume can be corrected by a peep level which allows the alveolus and terminal bronchiole to be continually distended during the entire ventilatory phase.

A flow-inflating bag does not directly control the quantity of gases for each breath, but enables the modulation of tidal volume according to obtained distension of the chest, acting on the valve which regulates gas exhalation. Maintaining the terminal bronchiole open at the end of expiration, peep allows the possibility of progressively reducing pip. Peep, achieved and regulated by means of the continuous distension of the bag, favors oxygenation and enables application of reduced tidal volume and high respiratory rate (low tidal volume strategy). This ventilatory mode has proved to be also extremely useful and protective in children with obstructive lung diseases (e.g. Bronchiolitis and asthma).

ATELECTRAUMA

Atelectasis is characterized by and associated with decreased compliance, impairment of oxygenation, increased pulmonary vascular resistance and development of lung injury. Atelectasis development has been demonstrated even if the patient is breathing spontaneously or is sedated and paralyzed and mechanically ventilated. It has been demonstrated that atelectasis can appear within a few minutes of sedation and muscle paralysis (e.g. Induction of anesthesia) [19,20].

Several mechanisms have been suggested in the development of atelectasis and the following have been considered mainly responsible: absorption of alveolar air, compression of lung tissue, and impairment of surfactant function[21]. Atelectasis is traditionally thought of as a consequence of lung region and alveoli collapse and not of intrathoracic fluid accumulation.

In children (aged 1–3 years) atelectasis develops more readily compared to adults due to the greater thoracic wall compliance resulting in less outwardly directed lung distension forces and because airway closure can occur even during tidal breathing (high airway closing volume). Abdominal distention (e.g. Pregnancy) and obesity represent two

important factors in determining gas exchange impairment and atelectasis.

Tidal volume and its stability, and suitable peep levels are important factors in avoiding atelectasis development and gas exchange impairment. When atelectasis does appear, recruiting maneuvers are necessary for its resolution and PEEP alone may be insufficient to re-ventilate atelectasic lung regions.

Use of continuous peep via flow-inflating bag

PEEP during resuscitation improves blood oxygenation due to increase of lung volume, surface area and compliance, prevents complete lung deflation during expiration and establishes FRC.

Peep during emergency ventilation in asthma and bronchiolitis allows recruited small airways and alveoli to be kept open by continuously distending the terminal bronchiole. Best emergency ventilation mode in these lung pathologies is low tidal volume strategy, high respiratory rate and application of continuous distending PEEP.

Setting peep needs early recruitment maneuvers. All children require a minimum of 5-10 cm h_2o peep. 12-15 cm h_2o peep is probably the best in specific clinical setting. Setting peep is in any case always a compromise[22].

Recruitment maneuvers

Manual lung recruitment is fundamental in reducing and resolving atelectasis and improving gas exchange [23,24]. Manual ventilation by bag is a simple maneuver and can be applied at the start of artificial ventilation or during the treatment when atelectasis occurs (e.g. After bronchosuctioning). In presence of inhomogeneous lung pathology or when the inflation pressure is not strictly controlled, over-distension of better-ventilated lung units can occur (barotrauma) during recruitment maneuver. At present the safe peak pressure to reach during distention and for how many seconds the lung must be maintained in distention are controversial. In adults some authors suggest applying 40 cmh_2o maintained for 8-15 seconds[8]. Others suggest maintaining plateau pressure <35 cm h_2o and 15 cmh_2o peep to avoid collapse of recruited lung[25].

The same pressures could be applied in severe lung pathology in children and adolescents over 8 years of age. In infants and young children these pressures appear harmful. Our suggestion is the use of 8-10 cm h_2o over preset inspiratory peak pressure[26]. In neonates recruiting pressure must be modulated in order to avoid an increase of intra-thoracic pressure over 35 cmh_2o.

OXYGEN SIDE EFFECTS

Oxygen, particularly when cold and dry, is toxic to the lung epithelium. Its use should be limited to when really needed. There are important changes in the current recommendation of 100% oxygen use and 100% o_2 should no longer be routine for newborn resuscitation[27-29].

RESUSCITATION WITH 100% OXYGEN

1. Produces more evidence of oxidative stress and may be deleterious;
2. Can be a powerful lung irritant and provoke an inflammatory response;
3. Could potentially exacerbate infant and child respiratory disease;
4. There is considerable concern about high arterial oxygen levels in very premature babies and their contribution to retinopathy and chronic lung disease.

Development of atelectasis is consequent to total re-absorption of o_2 in the alveoli. Most experience in this field derives from anesthesia. Using high fio_2 during pre-oxygenation or fio_2 1.0 before extubation exposes to risk of persistent atelectasis in postoperative care.

To avoid this risk, use the lower concentration of fio_2 accepting pao_2 values near the lower limit of the range, and sat o_2 of 90. To reduce the risk of oxygen toxicity from high fio_2, it is recommended to apply suitable procedures that lead to fio_2 reduction and

increase in oxygenation: PEEP titration e recruiting maneuvers[22].

Dry and cold oxygen (gas) also favors consolidation of secretions and difficulty in removal with consequent airway trauma and alveolar collapse/closure. Use of humidified and warmed ventilated gases is fundamental in reducing damage connected with bronchosuction in prolonged ventilation support.

Use of high fio_2 (>0.4) produces free oxygen radicals which cause direct damage to the lung and favor the release of inflammation mediators and development of multi organ failure (MOF) [30].

BIOTRAUMA

Biological lung damage is caused on the one hand by the lung pathology itself and on the other by damage to the lung from traumatic ventilation and oxygen supplementation[31].

Studies in animals have demonstrated that over-distension of the lung by mechanical ventilation can cause elevations in inflammatory cytokines, increased endothelial and epithelial permeability, alter lung fluid balance, and result in severe ultra structural tissue damage[32]. It is also certain that oxygen toxicity can cause elevated cytokine levels and therefore the use of oxygen must be carefully evaluated. High fio_2 and traumatic ventilation must be strictly evaluated in the realization of biotrauma.

Mediators released by the lung owing to the increased pulmonary stresses entering the circulation could lead to distal organ dysfunction and ultimately mof which seriously limit the patient's chances of recovery[32].

Reduction of lung stress, control of inflammation, reduction of fio_2 to minimum level, and use of protective lung strategies that limit end-inspiratory lung stretch in mechanically ventilated patients are fundamental in reducing biotrauma and protecting the lung from ventilation injury.

SURFACT-TRAUMA

Lack of surfactant activity in the lung can be connected with direct damage to alveolar cells or inhibition/inactivation of normally produced surfactant. Surfactant inhibition and the impossibility of recycling it (90% of surfactant produced is recycled) is a major cause of its loss of activity. There is evidence that alteration of the pulmonary surface may lead to lung inflammation and development of pneumonia[33].

Surfactant deficiency is connected with various exogenous and endogenous causes. Among exogenous causes, air pollution and the use of certain gases (e.g. Anesthetics, no) are becoming more important. Mechanical ventilation can deteriorate lung surfactant when high tidal volume is used, due to the increased conversion of surfactant from large aggregate to inactive form. Elevated levels of no and reactive oxygen species (free radicals) alter surfactant proteins, reducing its activity.

Suitable ventilation modes, use of not toxic gases, high quality nursing (e.g. No use of saline before aspiration but utilization of humidifiers to maintain fluid secretions) and reduced fio_2, are principal factors in surfactant protective strategy[34].

CONCLUSIONS

Complications and side effects of artificial ventilation cannot be avoided in emergency room but could be reduced by following manner and protocol of application carefully and accurately.

Auto-inflating bag and flow-inflating bag are referential for other systems currently on the market. Both systems can be used in various clinical contexts (e.g. Lung re-expansion after bronchosuctioning and/or treatment of uni-plurilobar atelectasis). Advantages and disadvantages of both systems must be evaluated before their use in order to obtain the best gas exchange with the least pulmonary damage.

The preset pressure control valve and the systems that utilize this valve can avoid the risk of elevated airway pressure (PIP) but are not able to assure lesser damage to the lung. Tidal volume plays a most important role in causing lung damage: it can favour either over-distension or hypoventilation, and both clinical conditions are harmful for the lung. Over-distension results in direct damage to the lung structure while hypoventilation favours the development of non–ventilating and atelectasic areas which complicate the clinical evolution and the final outcome. An important role during ventilation is also played by the correct use of peep: 1. Avoiding the closure and re-opening of the terminal bronchioles can reduce the need for high opening peak pressures; 2. Maintaining the alveolus continuously distended, peep on one hand improves oxygenation (increase of functional residual capacity – frc) and on the other reduces the need for high fio_2 (less oxygen toxicity). Maintaining the lung distended at the end of inspiration favours alveolar recruitment when tidal volume is introduced into the lung. The required duration of distension is controversial, although 8-15 seconds appears to be useful in adults and in children.

Ventilation of a child in emergency needs skill as well as adequate and updated knowledge not only to obtain beneficial effects from artificial ventilation but also to reduce side effects connected to incorrect use. It should be borne in mind that even short time ventilation can cause severe damage to the lung, not only immediately and evidently (e.g. Emphysema and pneumothorax) but also in the medium and long term, affecting morbidity and mortality of outcome.

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Obstructive Airway Diseases –I: Bronchiolitis

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BRONCHIOLITIS

Epidemiology and Etiology

Acute bronchiolitis is the most frequent and severe respiratory system syndrome involving children <2 years of age, with the peak incidence occurring at <12 months of age. Bronchiolitis is a seasonal disease with an epidemic pattern, with increase in prevalence during the fall and winter. It often coincides with the viral epidemics of respiratory infection.

The hallmark of the disease is bronchiolar inflammation and obstruction.

A wide range of agents (parainfluenza, adenovirus, influenza, Mycoplasma pneumoniae, rhinovirus, Chlamydia pneumoniae, human metapneumovirus, and coronavirus) may cause Bronchiolitis; however, RSV (with its A and B subtypes) is by far the most frequently involved agent.

Environmental and genetic factors contribute to disease severity. Passive tobacco exposure increases hospitalization risk in bronchiolitis .

Clinical profile

Typically, it begins with initial symptoms of an upper airway viral infection, such as fever and coryza. Children have abundant rhinorrhea and cough, along with poor food intake (4-6 days after symptoms start). The degree of fever in infants depends on the infecting organism. Children experiencing bronchiolitis caused by RSV are frequently febrile by the time of consultation (>38.5°C, in 50% of patients), and those with influenza or parainfluenza usually have a fever >39°C.

Within 4-6 days, the lower respiratory tract is involved, with clinical signs of cough, tachypnea, hyperinflation, chest retractions, widespread crackles, and wheezing. Children <6 months old are at increased risk for developing severe bronchiolitis disease. Physical examination may reveal audible wheezing, crackles, or rhonchi (apical ventilatory pattern), and a prolonged expiratory phase. Other common findings are conjunctivitis, acute otitis, and rhinitis. Many infants have a distended abdomen.

Wood and Downe had devised a scoring system for grading the severity of Bronchiolitis which is a useful tool to monitor disease course as well as therapy (See Table 1). [(1)]

The risk factors for clinical worsening of acute bronchiolitis include the following:

1. Initial presentation**:** Tachypnea (RR >60-80 bpm or retractions), Hypoxia (SaO_2 90%-95%),Feeding difficulty or dehydration
2. Age: <12 months (the younger the child, larger the risk).
3. Comorbidities: Bronchopulmonary dysplasia, Congenital heart disease

   Cystic fibrosis, Immunodeficiency.
4. Prematurity: Gestation age <36 weeks
5. Others: Malnutrition, Poverty, Overcrowding, Parents and/or family members who smoke ,Genetic RSV infection predisposition

LABORATORY INVESTIGATIONS

A mild leukocytosis with a normal differential is frequently found in infants

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experiencing bronchiolitis. Hypoxia is detected by pulse oximetry or arterial blood gases. CO_2 retention may be seen in severe cases.

Viruses may be detected from nasal samples by indirect fluorescence antibody detection, PCR, radioimmunoassay, or direct culture.

Chest x-rays often show nonspecific findings, including hyperinflation, gross infiltrates that are typically migratory and attributable to postobstructive atelectasis, and peribronchial filling. Bronchiolitis is not an alveolar space disease and, when a true alveolar infiltrate is seen, secondary bacterial pneumonia should be suspected.

Table 1: Wood-Downes Score: Used to evaluate and grade bronchiolitis severity

Score*	Wheezing	Retraction	RR	HR	Ventilation	Cyanosis
0	No	No	<30	<120	Good symmetrical	No
1	End expiratory	Subcostal/intercostals	31-45	>120	Regular symmetrical	Yes
2	All expiration	Supraclavicular+ nasal flaring	40-60		Very reduced	
3	Inspiration and expiration	+Intercostal+ suprasternal			Silent thorax	

*The highest scores from each column are summed to attain the total severity score: 1-3, mild; 4-7, moderate; 8-14, severe

TREATMENT

Clinical judgment remains the gold-standard criterion for hospital admission and cannot be replaced by objective criterion.

Arterial O_2 saturation (SaO_2) is the most consistent clinical predictor of a worsening clinical condition (the cut-off point ranging from 90% to 95%).

Most severe disease are found in patients with SaO_2 <95%, prematurity (<34 weeks of gestational age), congenital heart disease, neurologic disease, RR >70 bpm, pulmonary atelectasis, sick or toxic appearance, and age <3 months.

The single best predictor of a more severe total disease course is arterial saturation of <95% on pulse oximetry[1].Generally, the predictors of the need for intensive care are RR>80 bpm and hypoxia with SaO_2 <85%[2].

HYDRATION AND OXYGENATION

Adequate hydration and oxygenation are the backbone of bronchiolitis treatment. IV fluids and O_2 support is essential, when feeding is not tolerated. Supplemental O_2, is the single most useful therapy. SaO_2 should be kept over 92%[3]. Careful monitoring, mainly among the more sick and high-risk children, is important, as more aggressive ventilatory support may be required (mask, nasopharyngeal continuous positive airway pressure ventilation, or even endotracheal ventilation), and the timely introduction of ventilatory support is important to prevent further complications

BETA-2 AGONISTS

Still has no scientifically defined recommendation. If clinical improvement does not immediately occur or if worsening is observed after 60 mins of inhalation, beta-2 agonists should be discontinued. As beta-2 agonists help to relieve bronchoconstriction, the degree of their effectiveness can be expected to be directly related to the contribution of bronchoconstriction to wheezing (i.e., the greater the contribution, the more effective the agonists). Bronchodilator treatment is more effective when administered early.[4]

RACEMIC EPINEPHRINE

Racemic epinephrine 2.25% and L-epinephrine 0.1% are used at 0.1 mg/kg and 0.05 mg/kg, respectively, every 4 hrs. This treatment should only be used in the hospital setting with clinical, heart rate, and electrocardiographic monitoring. As a rebound effect may occur, the child should be observed for at least 1-2 hrs following cessation of treatment and a decision to discharge prematurely should be avoided.

In a study conducted in centre for child health, SGRH, New Delhi 14 were admitted in the salbutamol group as against 10 in the adrenaline group, study showed good efficacy with adrenaline being better than salbutamol in preventing hospital admission rates.(unpublished data)

INHALED AND SYSTEMIC STEROIDS

The use of inhaled and systemic steroids is also a controversial therapy, as these agents may produce little or no response at all.[5]

AEROSOLIZED RECOMBINANT HUMAN DNASE

Mucus in patients with cystic fibrosis, bronchiectasias, and RSV bronchiolitis was shown to contain significant extracellular DNA from degenerated leukocytes and epithelial debris (6). DNA increased pulmonary secretion viscosity and adhesiveness, hence DNAse has been tried in bronchiolitis and results have not been very encouraging. DNAse may also be effective in infections complicated by atelectasis, bronchial secretions, and mucous plugs that have high DNA concentration.

RIBAVIRIN

Ribavirin is an antiviral drug that inhibits the structural protein synthesis of the virus, reducing viral replication and immunoglobulin (Ig) E response. Following the initial excitement regarding this drug, problematic issues arose related to its high cost, logistic issues, has to be given as continous aerosol over several hours, possible teratogenesis, and low clinical efficacy. It has to be given as continous aerosol over several hours. A Cochrane review found no conclusive evidence that ribavirin use is beneficial for bronchiolitis due to RSV[7].

ANTIBIOTICS

Antibiotics have no benefit in treating RSV but are important in treating secondary bacterial infection, such as Streptococcus and Staphylococcus, which can occur following initial RSV infection.[5]

OTHER MEASURES

Heliox

The helium-oxygen mixture (heliox) reduces the work of breathing and expiratory wheezing in children with obstructive disease . It is recommended that its use should be restricted to the intensive care setting. However it has not been found to be clinically beneficial.

Respiratory Physiotherapy

In a systematic review, the recommended techniques for children with bronchiolitis are based on positioning therapy, alveolar

recruitment and expiratory airflow increase using hand vibration[8]. Due to copious airway secretions in RSV, airway suctioning is an effective measure for tracheobronchial hygiene. Approximately 60% of respiratory resistance is in the upper airways, and as infants predominantly breathe through the nose, the clearance of these secretions may have a positive impact on work of breathing and relieve symptoms.

Extracorporeal Membrane Oxygenation

Extracorporeal membrane oxygenation (ECMO) is an option for severely ill children who cannot be supported by conventional mechanical ventilation due to their ventilation and cardiocirculatory condition. While use of ECMO for RSV is infrequent, good survival has been obtained, even with prolonged durations of this support while the patient is awaiting lung recovery[9].

Inhaled Nitric Oxide

Nitric oxide used in the treatment of children severely infected with RSV improved oxygenation and respiratory system resistance.[10] The use of this therapy should be reserved for patients with severe hypoxemia, refractory to ventilatory support.

Exogenous Surfactant

Children with bronchiolitis infected by RSV have surfactant deficiency. The use of exogenous surfactant as potential treatment for bronchiolitis patients was evaluated, and the results suggest that surfactant has an important role on small-airway patency as well as on pulmonary compliance; however, its use is restricted to patients in the ICU.[11]

Conventional Mechanical Pulmonary Ventilation

Conventional mechanical ventilation, using pressure-control ventilation mode, is indicated in those children with either obstructive or restrictive hypoxemic disease; however, a mixed mode (pressure regulated, volume controlled) can also be chosen. Due to the possibility of intrinsic positive end-expiratory pressure (PEEP), efforts should be focused on maintaining a low RR (20 bpm) and an inspiratory:expiratory ratio of 1:3. Additionally, the initial PEEP should be ~5 cm H_2O, with adjustments being made according to the degree of alveolar recruitment and clinical response.

High-frequency Oscillation Ventilation

High-frequency oscillation ventilation is indicated for those patients whose condition continues to worsen despite conventional mechanical ventilation or for those with significant air leak (pneumothorax, interstitial emphysema, pneumopericardium). It is also indicated for patients with restrictive disease, with an oxygenation index >13 at some centers. The main advantage of this therapy is the possibility of optimizing ventilation and oxygenation with a lower risk of pulmonary injury induced by mechanical ventilation.

Noninvasive Positive-pressure Ventilation

Noninvasive positive-pressure ventilation use in bronchiolitis children keeps airways open, improves respiratory flow, maintains functional residual capacity, improves pulmonary compliance, facilitates secretion mobilization, reduces work of breathing, improves gas exchange, and preserves surfactant synthesis and release. This therapy is indicated as first-choice ventilatory support in children who are experiencing apnea episodes and for preventing the use of invasive mechanical ventilation. This noninvasive support can be performed using continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) ventilatory mode. New modes of high-flow nasal cannula therapy with devices such as Vapotherm may also be advantageous in some patients. When CPAP is chosen, it is recommended to start with 4-6 cm H_2O; if BiPAP is chosen, it is recommended to begin with an inspiratory pressure of 8 cm H_2O and expiratory positive airway pressure of 4 cm H_2O. Noninvasive positive-pressure ventilation parameter changes should be titrated to the child's clinical response.

PROPHYLAXIS

Preventing RSV infection in young infants, mostly in those at high risk, is clearly the best

strategy. Two measures are availble for preventing RSV infection: use of vaccines (active immunization) and parenteral immunoglobulins. Efforts to obtain an effective vaccine have not yet yielded positive results. Passive immunization against RSV may be made with monoclonal antibodies (palivizumab, approved by the US Food and Drug Administration in 1998). Once per month during the epidemic months, an intramuscular dose of 15 mg/kg should be administered. Premature infants with chronic pulmonary disease benefit more from palivizumab, its use is indicated in children with congenital heart disease and significant hemodynamic impairment[12].

PROGNOSIS

Most children with bronchiolitis, regardless of severity, recover without sequelae. The natural course of the disease usually ranges from 7 to 10 days; however, some children remain ill for weeks. More than half of bronchiolitis patients have recurring episodes of wheezing till 7-11 years of age ref. Children predisposed to asthma may wheeze more when infected by RSV or another allergic stimulus.

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Notes and News

Pediatric Advanced Life Support (PALS) Course

(4th-5th December, 2010)

The Department of Pediatrics, Dr RML Hospital, New Delhi, in collaboration with the Indian academy of Pediatrics - PALS group is organizing a PALS (provider) course at PGIMER, Dr RML Hospital on the 4th and 5th of December 2010. The registration will be restricted to 36 delegates on first-come first-serve basis. The registration fee is Rs 2500/- (including course material) which has to be sent by cheque/cash/bank draft in favor of "PALS RML PGIMER" and mailed to Organizing Secretary. For registration and details, kindly contact.

Organizing Secretary

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This book has been addressed to young doctors who take care of children, such as postgraduate students, junior doctors working in various capacities in Pediatrics and private practitioners. Standard Pediatric practices as well as diseases have been described in a nutshell. List of causes, differential diagnosis and tips for examination have been given to help examination-going students revise it quickly. Parent guidance techniques, vaccination and food have been included for private practitioners and family physicians that see a large child population in our country. Parents can have some understanding of how the doctors will try to manage a particular condition in a child systematically. A list of commonly used pediatric drugs and dosage is also given. Some views on controversies in Pediatrics have also been included. Few important techniques have been described which include procedures like endotracheal intubations, collecting blood samples and ventilation. I hope this book helps young doctors serve children better.

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Role of Radiology in emergencies I - Neuroinfections: Tuberculous Meningitis

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ABSTRACT

Tuberculous CNS infections and especially tuberculous meningitis [TBM], still account for major morbidity and mortality in developing countries. While effective treatment is available now, the need for rapid and accurate diagnosis, along with the tendency toward non-invasiveness in this age has turned the attention to the radiologist, who must equip himself with the latest that the field has to offer. Indeed, the role of radiology, especially CT and MR imaging, is rapidly evolving, and includes not just diagnosis but also extent and complication assessment, outcome measures and even treatment. This article reviews the role of imaging in the diagnosis of TBM, along with a discussion of other manifestations of CNS tuberculosis, and the imaging differential that must be kept in mind.

Key words: Tuberculosis; tuberculous meningitis; tuberculoma; meningeal enhancement; magnetic resonance imaging, vasculitis; hydrocephalus; ring enhancing lesion.

INTRODUCTION

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*,[1] accounts for eight million worldwide deaths annually. Involvement of the central nervous system (CNS) is one of the most serious forms of this infection, and is responsible for a high mortality and morbidity, more so in children in background of protein energy malnutrition.

Tuberculous meningitis (TBM) is the most life-threatening and most common presentation of central nervous system (CNS) tuberculosis in infants and children, with the highest incidence in the first three years of life. Its presentation is often nonspecific, characteristic signs and symptoms of meningitis may be absent, and early recognition of this potentially treatable disease remains a challenge to clinicians. Early diagnosis followed by effective treatment can prevent neurologic damage or a fatal outcome [2, 3].

Clinical manifestations of TBM in children include personality change, irritability, anorexia, and fever. Drowsiness, vomiting, neck stiffness, cranial neuropathies and depressed reflexes follow in 1 to 2 weeks, with stupor, coma, stroke and decerebrate rigidity in late stages.[4] If untreated, TBM rapidly progresses to death within just 3 weeks.

Routine diagnostic techniques involve culture and immunological tests of the tissue and biofluids, which are time-consuming and may delay definitive management. The increasing role of noninvasive imaging modalities such as computed tomography (CT)

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and Magnetic Resonance Imaging (MRI) in the diagnosis and detection of various complications of CNS tuberculosis is therefore of paramount interest to both the clinician and the radiologist. The current article reviews the role of various imaging techniques in the diagnosis and management of CNS TB with a discussion of the differential diagnosis.

PATHOGENESIS

Most tuberculous infections of the CNS are caused by *Mycobacterium tuberculosis* and less frequently by *M.bovis*.M.tuberculosis enters the pulmonary alveoli as droplets to produce a localized infection of the lungs and draining lymph nodes termed the 'primary complex'. A transient but significant bacteremia ensues during the first week after infection, with resultant hematogenous dissemination of bacilli to various organs of the body including the brain and meninges. Small subpial or subependymal foci of tuberculous caseous lesions termed 'Rich Foci' develop in the CNS and can enlarge and become active after a quiescient period,even several years after initial infection.[5]

The location of the expanding Rich Foci determines the type of CNS involvement. Tubercles rupturing into the subarachnoid space cause meningitis[2,3]. Those deeper in the brain and spinal cord parenchyma cause tuberculoma, abscesses or tuberculous cerebritis.

In TBM, thick gelatinous exudates form around sylvian fissures, basal cisterns, brain stem and cerebellum blocking the subarachnoid spaces resulting in hydrocephalus.

The meningeal inflammatory exudates infiltrate the blood vessels leading to necrotizing panarteritis with secondary thrombosis and occlusion. The basal ganglia and thalamus in the region of lenticulostriate and thalamoperforating arteries are most commonly involved by this vasculitis.[6] The perineurium of cranial nerves is infiltrated causing neuropathies, particularly of cranial nerves II, VI and VII.

Intracranial tuberculomas originate as a conglomerate of microgranulomata in an area of tuberculous cerebritis that coalesce to form a noncaseating tuberculoma with subsequent central caseous necrosis that is initially solid, but may eventually liquefy later.[7]

The symptoms, signs, and sequelae of tuberculous meningitis (TBM) are the result of an immunologically directed inflammatory reaction to the infection.

IMAGING OF TBM

Chest radiography may reveal hilar lymphadenopathy, pneumonia, infiltrates or pleural effusion. Skull radiography may reveal evidence of increased intracranial tension in children, in the form of sutural diastasis. Intracranial calcifications may be rarely evident in the sellar regions on follow-up. CT and MRI of the brain reveal hydrocephalus, basilar meningeal thickening and enhancement, abnormal enhancement of choroid plexus and ependymal lining. Co-existing tuberculomas and underlying infarcts may also be evident.

MRI scores over CT scans in the early detection of meningeal pathologies (8). During the early stages of the disease, non contrast MRI shows little or no meningeal abnormality. With disease progression, non contrast CT or MRI studies show partial or complete obliteration of basal cisterns and sylvian fissures by the purulent tuberculous exudates which show density or signal intensity similar to that of adjacent brain (Fig. 2A,4A, B). On contrast CT or MRI studies, intense and homogenous leptomeningeal enhancement is seen in the basal cisterns (Fig. 1A,B,2C). Commonly involved sites are the interpeduncular fossa, pontine cistern, perimesencephalic and suprasellar cisterns, cerebral convexities and the Sylvian fissures.[8,9,10] The leptomeningeal enhancement in MRI is due to contrast within dilated and engorged vessels in meningeal granulation tissue and also due to the contrast leak from disruption of blood meningeal barrier. Meningeal enhancement is not specific

for TBM, and is also seen in other infections like cryptococcal meningitis, neurosyphilis, Lyme disease, neurosarcoidosis and carcinomatous dissemination. Calcifications can be seen in the basal cisterns few years after the onset of disease and is better shown with CT scans.

COMPLICATIONS OF TUBERCULOUS MENINGITIS

Hydrocephalus

Ventriculomegaly is seen in 50 to 77% of affected patients and may be the only abnormal finding in patients with meningitis. Hydrocephalus encountered in TBM can be broadly divided into two types: **(1) communicating type**, which is common, secondary to obstruction of cisterns by inflammatory exudates or due to arachnoid adhesions impairing extraventricular CSF flow and absorption and **(2) obstructive type**, which is less common, due to cellular debris or parenchymal lesions obstructing the fourth ventricular foramina, cerebral aqueduct or entrapment of a part of the ventricle by granulomatous ependymitis.[11] Periventricular hypodensity on CT scans (Fig. 2B,D) and hyperintensity on proton density and T2-FLAIR images is due to the subependymal seepage of the CSF across the white matter and usually suggests hydrocephalus under pressure, which is an indication for CSF diversion surgery to decompress the ventricular system. Chronic hydrocephalus may result in atrophy of the brain parenchyma. Ependymitis, when present is seen as linear enhancement along the ventricular margins on post contrast MRI.

VASCULITIS

Ischemic cerebral infarction resulting from the vascular occlusion is a common sequelae of tuberculous arteritis. The middle cerebral and lenticulostriate arteries are most commonly affected. CT and MR angiography help in the detection of vascular occlusion, stenosis and irregularity of medium or small sized blood vessels. The incidence of infarcts detected by CT scan varies from 20.5 to 38%. MRI detects more infarcts, including hemorrhagic infarcts, than does CT[12]. The majority of the infarcts are in the basal ganglia, thalami and internal capsule due to the involvement of the lenticulostriate arteries. [13] (Fig. 4C,D) Cortical infarctions can result from involvement of cortical vessels but are less common. The infarcts appear as low density regions on CT (Fig. 1A-D) and as high signal intensity areas on T2, FLAIR and diffusion weighted MRI images (Fig. 7A,B). Diffusion-weighted imaging helps in the early detection of this complication,[13] with low ADC values pointing toward acute stage of infarction.

TUBERCULOMAS

Tubercular meningitis may be associated with meningeal and parenchymal tuberculomas in 20 to 30 % of cases. When tuberculoma and TBM are seen together, the diagnosis of tuberculosis is easily made. Children predominantly have infratentorial tuberculomas whereas adults usually have lesions in the supratentorial compartment. Tuberculomas may be single or multiple ranging from 1 to 12 lesions or more, the sizes varying from 1mm to 8cm.[14]

On non contrast CT, Tuberculomas are seen as rounded lesions often as dense as or slightly denser than brain with moderate to marked vasogenic edema in adjoining white matter. On contrast enhanced CT, tuberculomas commonly show ring enhancement (Fig. 1C, 2C,D) or less likely nodular or irregular nonhomogenous enhancement. When multiple they are often clustered or conglomerate to form thick walled and irregular peripherally enhancing lesions with hypodense centre and florid perilesional edema. Ring enhancing lesions with central nidus of calcification termed as the target sign is characteristic of tuberculoma.[15] (Fig. 3A,B)

The MRI features of tuberculomas depend on its stage of maturation, i.e., whether noncaseating, caseating with a solid center,

or caseating with a liquid center.[16,17] Tuberculomas show marked perilesional edema seen as high signal intensity on T2W and FLAIR images confined to the white matter.

A noncaseating tuberculoma appears hyperintense on T2W and slightly hypointense on T1W images and show homogenous enhancement after injection of gadolinium contrast on T1W images [18]. A solid caseating tuberculoma appears iso- to hypointense on both T1W and T2W images with an iso to hyperintense rim on T2W images and shows rim enhancement on postcontrast T1W images (Fig 5A-D,6A). When the solid center of the caseating lesion liquefies, the center appears hyperintense with a hypointense rim on T2W images. The postcontrast T1W images show rim enhancement.

On MR spectroscopy, tuberculomas shows characteristic lipid peaks with additional choline peaks indicating increased cellularity in lesions with heterogeneous appearance[19]. Miliary brain tuberculosis is usually associated with TBM. Contrast enhanced T1W images show numerous, round, small, homogeneous, enhancing tubercles of <2 mm in size. The CT and MRI features of tuberculomas are summarized in Tables 1 and 2.

Intracranial focal lesions like healing stage of neurocysticercosis, fungal granulomas, chronic pyogenic brain abscess, metastases and lymphomas may have features similar to those of tuberculomas and should be considered in the differential diagnoses.[20] Sometimes large tuberculomas showing heterogeneous signal intensity and contrast enhancement can mimic neoplasms like gliomas. The imaging differential diagnosis of intracranial tuberculomas is summarized in Table 3.

TUBERCULOUS BRAIN ABSCESS

It is a relatively rare condition and appears as large, solitary, and frequently multiloculated, ring-enhancing lesions with surrounding edema and mass effect on MRI.[21] They are indistinguishable from pyogenic brain abscesses on CT and MRI and surgery is the treatment of choice.

TUBERCULOUS SPINAL MENINGITIS

Spinal meningitis and spinal arachnoiditis are inflammatory spinal diseases caused by *M.tuberculosis*. MRI features include CSF loculation, obliteration of the spinal subarachnoid space and matting of the nerve roots. Postcontrast images show thick, nodular intradural meningeal enhancement often filling the subarachnoid space Spinal cord infarction and syringomyelia are the possible complications of arachnoiditis. TB myelitis with intramedullary, intradural and extradural abscesses and spinal cord tuberculomas may also occur.[22,23]

ASSESSMENT OF TREATMENT RESPONSE

Follow up imaging of CNS tuberculosis patients on ATT show less intense meningeal enhancement and decrease in size of the lesions within 3 to 4 months of start of ATT with almost complete disappearance of lesions at the end of 12 months. Paradoxical increase in size of the lesions or development of new lesions on imaging during antituberculous chemotherapy has also been recognized as a rare immunological response to ATT.[24]

CONCLUSION

Noninvasive imaging modalities such as CT and MRI supplemented by advanced MRI techniques like MR Spectroscopy and Diffusion weighted imaging offer greater inherent sensitivity and specificity in the diagnosis and follow-up of complications of CNS tuberculosis, thus helping in better management of these patients.

Table 1: Imaging features of intracranial tuberculomas on CT

Non-contrast CT	Contrast-enhanced CT
• Rounded iso-hyperdense lesions. • Perilesional white matter edema.	• Ring/nodular/irregular enhancement. • Conglomerate/tandem lesions. • 'Target sign': REL with central calcific nidus.

REL: Ring Enhancing Lesion

Table 2: Imaging features of intracranial tuberculomas on MRI

Type	T1-W	T2-W	Contrast enhanced	MRS
Noncaseating	Hypointense	Hyperintense	Homogenous	Cholinepeak
Caseating with solid centre	Iso-hypointense	Iso-hypointense with hyperintense rim	Rim enhancement	Lipid peak +/- Choline peak
Caseating with liquid centre	Iso-hyperintense	Hyperintense with hypointense rim	Rim enhancement	Lipid peak

MRS: Magnetic Resonance Spectroscopy

Table 3: Differential diagnosis of intracranial tuberculomas on CT & MRI

Pathology	Salient imaging features
Tuberculoma	Ring enhancing lesions with perilesional edema. Target sign. Conglomerate lesions. Size usually > 1 cm [except miliary tubercles] T2 hypointensity due to solid caseation. Choline and/or lipid peak on MRS. Restricted diffusion on DWI.
Neurocysticercosis	Ring enhancing lesions usually at grey-white junction. Most lesions < 1 cm. Eccentric mural-based scolex seen. Various stages of lesions [vesicular, colloid-vesicular granular-nodular, nodular-calcified]
Fungal granulomas	Immunocompromised state. Predominantly in thalamus/ basal ganglia. T2 hypointense center due to heavy metal accumulation.
Pyogenic abscess	Ring enhancing lesion. Medial wall thinner. Restricted diffusion on DWI. Lipid-lactate peaks on MRS.
Metastasis	Ring/nodular enhancing lesion. Disproportionate white matter edema. Adjacent meningeal spread.

Fig.1: TBM complicated by vasculitis and cerebral infarction. Contrast enhanced CT scan A–D show meningeal enhancement in suprasellar cistern, around left middle cerebral artery and in left frontoparietal sulci. A large hypodensity suggestive of infarct is seen involving left anterior and middle cerebral artery territory. C-Coexisting tuberculoma showing rim enhancement and perilesional edema is seen in right frontal lobe.

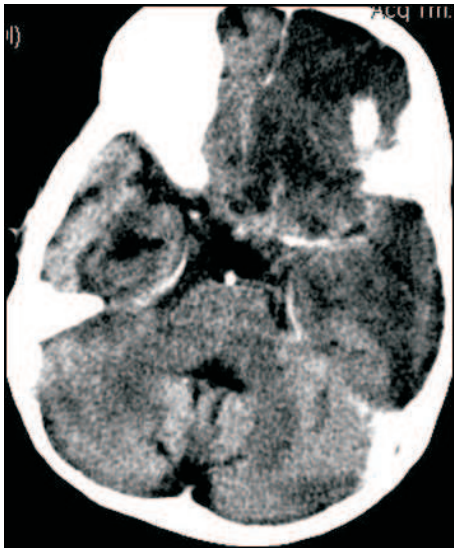

Fig.1A

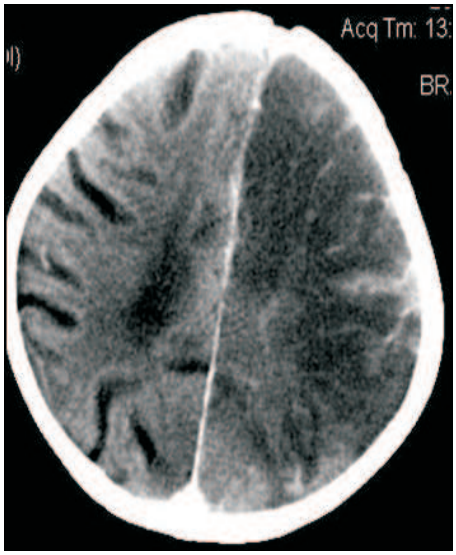

Fig.1B

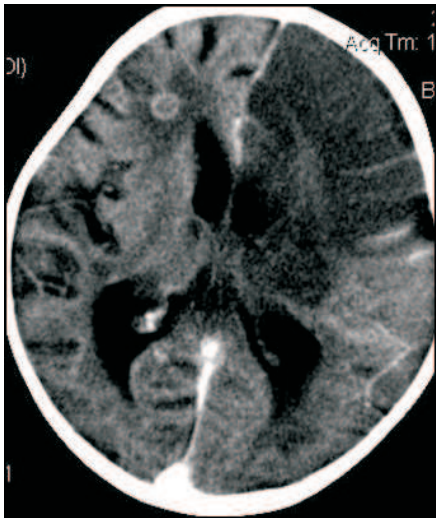

Fig.1C

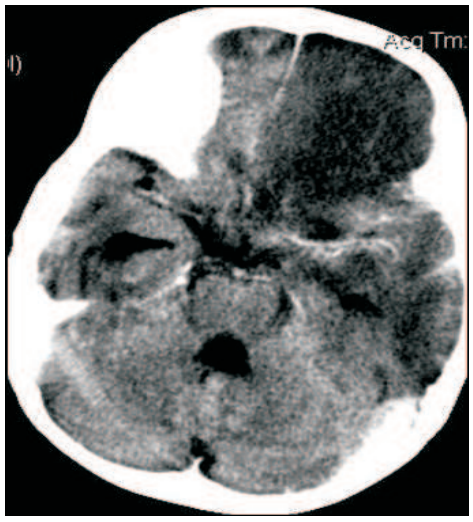

Fig.1D

Fig. 2: TBM and tuberculomas. A&B. Plain CT brain show obliteration of suprasellar and perimesencephalic cisterns by isodense inflammatory exudates. Dilated lateral ventricles with periventricular edema is also seen. C.&D - Contast CT show meningeal enhancement in suprasellar and perimesencephalic cisterns, multiple ring enhancing lesions are seen in right perisylvian region, periaqueductal mid brain and bilateral parasagital frontal lobes. Hydrocephalus with periventricular edema is also seen.

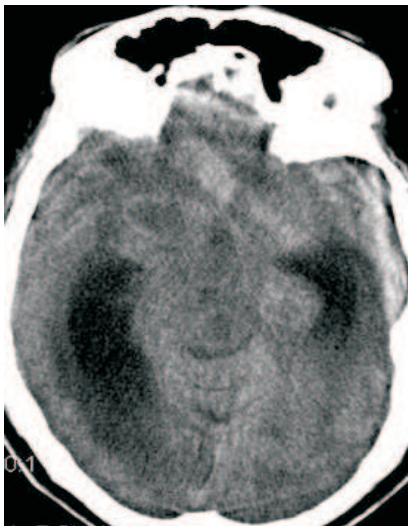

Fig.2A

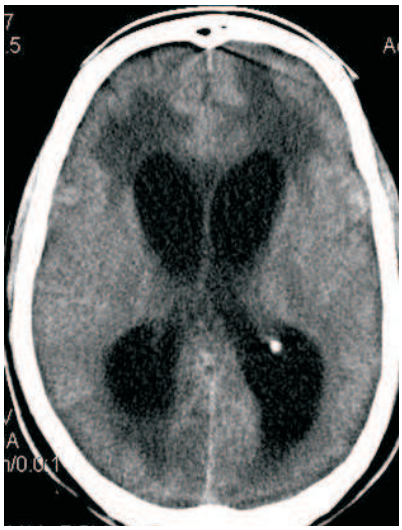

Fig.2B

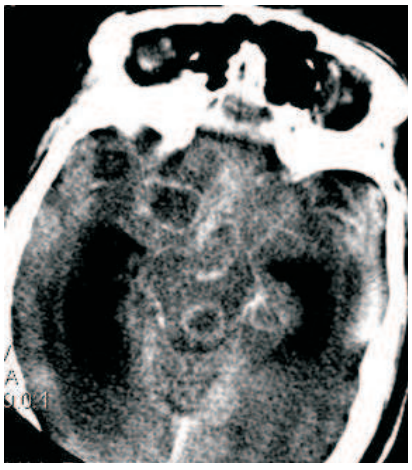

Fig.2C

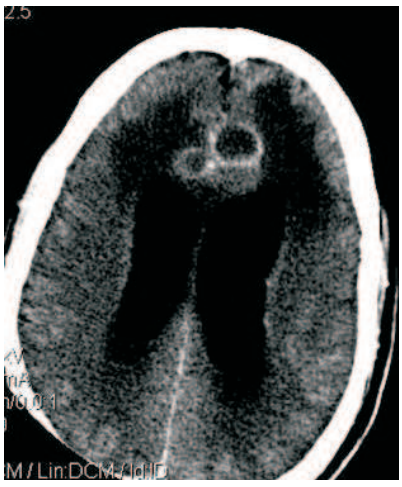

Fig.2D

Fig. 3: Tuberculoma (A) Plain CT brain show a round isodense lesion with central calcification and perilesional edema in left frontal lobe (B)Contrast CT shows ring enhancement with central calcification –"Target sign"

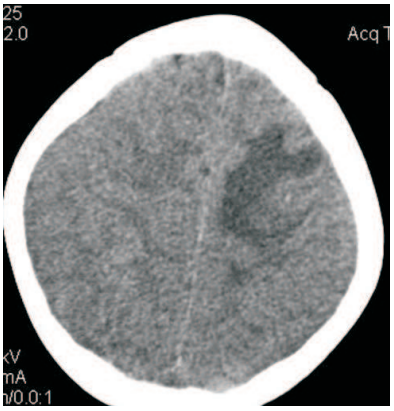

Fig.3A

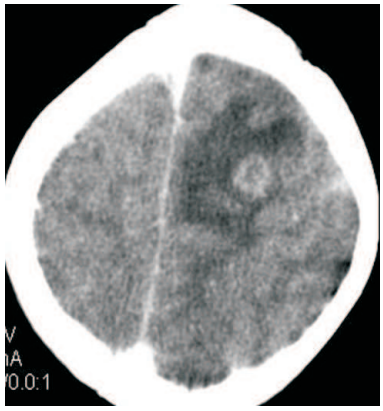

Fig.3B

Fig. 4: CNS Tuberculosis with vasculitis - MRI A –T2W, B- FLAIR MRI axial images show iso to hypointense areas filling the suprasellar and interpeduncular cisterns with hyperintense areas in bilateral temporal whitematter and midbrain suggestive of edema. C-T1W, D-T2W axial images show T1 hypointense and T2 hyperintense region in left lentiform nucleus consistent with vasculitic infarct

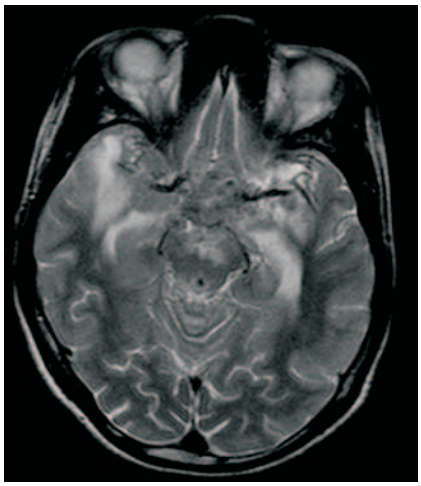

Fig.4A

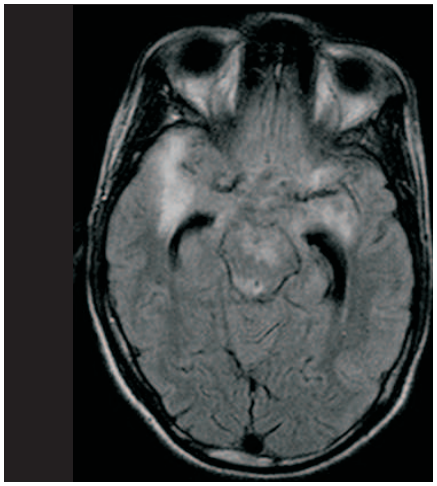

Fig.4B

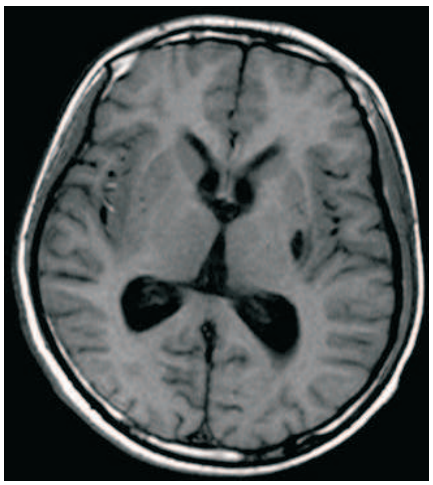

Fig.4C

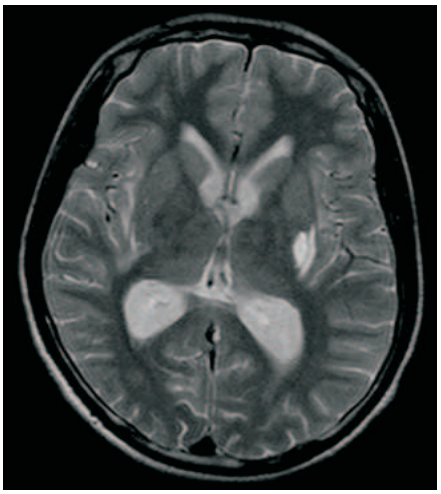

Fig.4D

Fig. 5: Cisternal and parenchymal tuberculomas. Gadolinium enhanced T1W MRI of the same patient as in Fig4. A&B–axial, C-coronal, D-sagital images show mutiple conglomerate ring enhancing lesions with hypointense centre consistent with tuberculomas in sellar, suprasellar, interpeduncular, prepontine, bilateral sylvian, right ambient cisterns and bilateral perisylvian temporal lobes

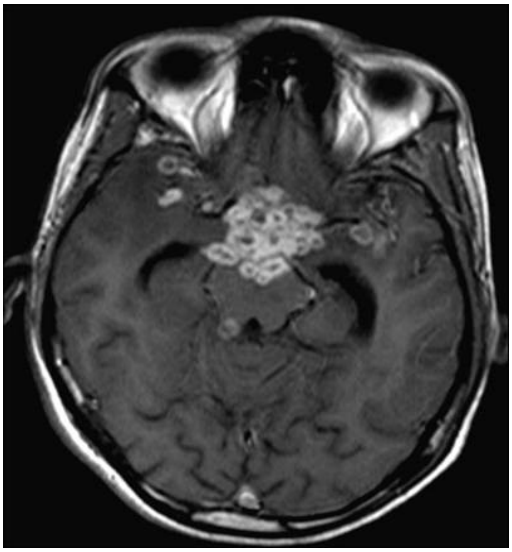

Fig.5A

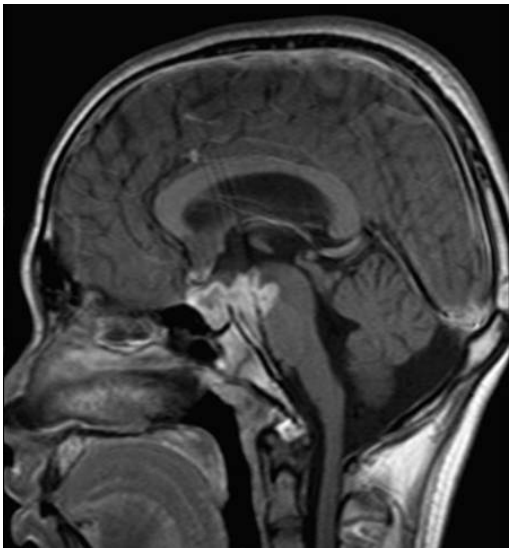

Fig.5B

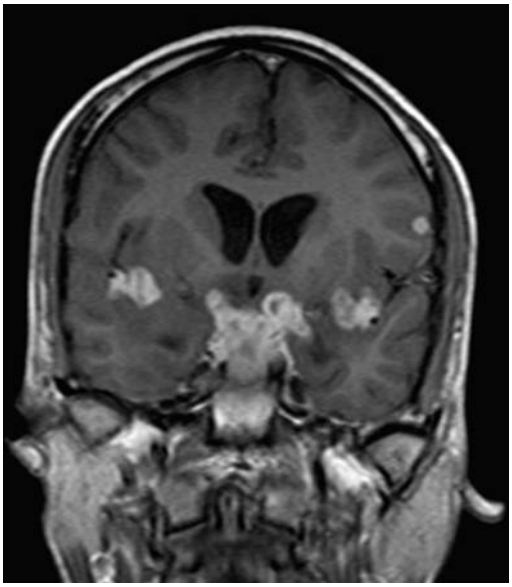

Fig.5C

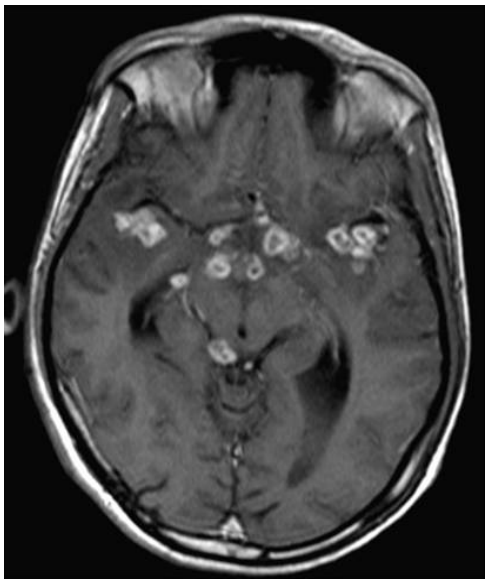

Fig.5D

Fig. 6: Tuberculoma left parietal lobe MRI A- Gadolinium enhanced T1W axial image show hypointense tuberculoma showing rim enhancement. B- FLAIR axial image show hyperintense tuberculoma with thin hypointense rim and perilesional edema. C- Diffusion weighted image show hypointensity with no restricted diffusion suggestive of tuberculoma with solid caseation.

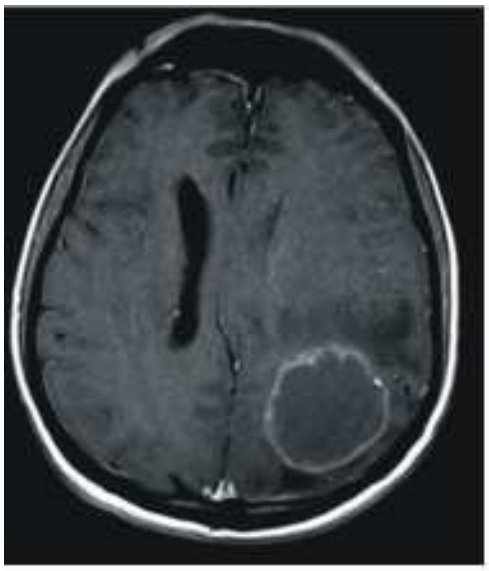

Fig.6A

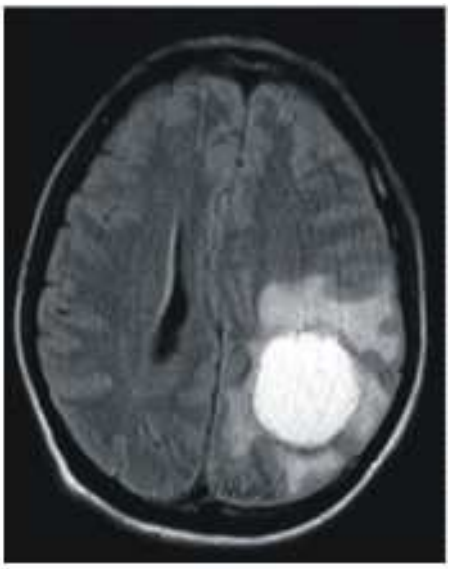

Fig.6B

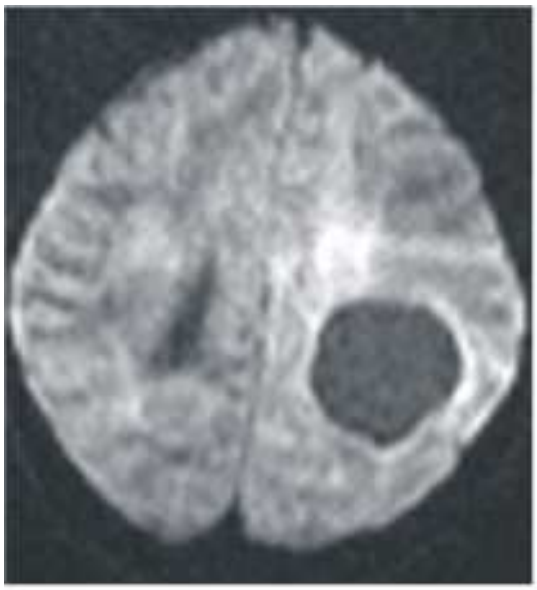

Fig.6C

Fig. 7: TBM complicated by vasculitis- MRI. A-FLAIR & B-Diffusion weighted images – show hyperintense areas consistent with infarcts in bilateral cerebral cortex.

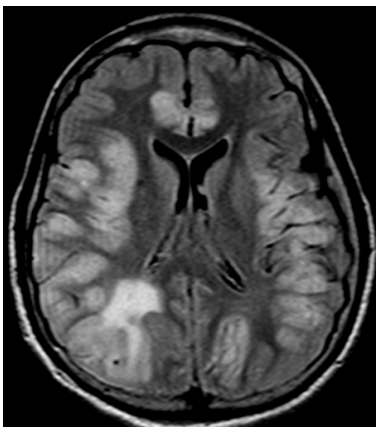

Fig.7A

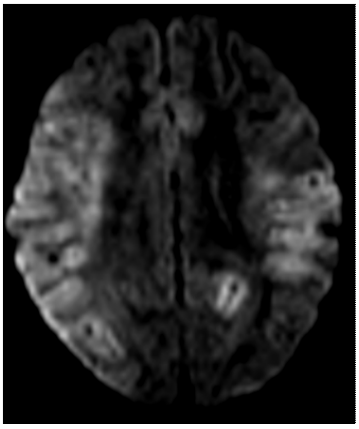

Fig.7B

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Management of Pediatric emergencies: Septic shock

Jhuma Sankar

ABSTRACT

Septic shock is a common cause of admission to the pediatric emergency and Pediatric Intensive Care Units requiring prompt recognition and management. The dynamic nature of the illness and the high mortality and morbidity rates associated with it make septic shock the most challenging disease to treat. Early recognition and aggressive time bound resuscitation is the key to successful outcome in children with septic shock. Therefore, guidelines for the management of septic shock laid down by the Surviving sepsis Campaign Committee are base on these principles. In this article, the physiologic principles behind shock states, the types of septic shock and the management of septic shock are discussed in detail with a special reference to resource restricted settings.

Key Words: sepsis, septic shock, physiologic principles, surviving sepsis campaign guidelines, Early goal directed Therapy, mixed venous oxygen saturation

INTRODUCTION

Shock is a clinical state characterized by inadequate tissue perfusion resulting from delivery of oxygen and metabolic substrates that is insufficient to meet metabolic demands. If unchecked, it leads to anaerobic metabolism and tissue acidosis thus causing irreversible cell damage. Treatment of shock should be aimed at maintaining the perfusion pressure above the critical point below which blood flow cannot be effectively maintained in individual organs. This is possible only with timely recognition and goal directed therapy. The outcome of unrecognized and untreated shock is universally lethal, be it in adults or children. [1,2,3]

Septic shock (SS) is a frequent cause of admission to the pediatric intensive care unit requiring prompt recognition and intervention. Septic shock and multi-organ dysfunction are the most common causes of death in patients with sepsis. The mortality rates associated with severe sepsis and septic shock reported from developed countries are 10% for children with severe sepsis and about 50% for children with septic shock.[4,5] The figures reported from Indian ICUs are also higher ranging from 40%-67%. [6, 7, 8] However, with increasing awareness of the importance of time sensitive goal-directed therapies we hope that this mortality rate will show a declining trend in future.

For the purpose of the article, the discussion of septic shock would be restricted to the physiologic principles, clinical features and management of septic shock on the basis of the surviving sepsis campaign guidelines. [9] The interested reader is referred to pediatric critical care books and literature available on sepsis and septic shock for a complete reading. [1, 2, 10,11]

PHYSIOLOGIC PRINCIPLES OF SHOCK

Determinants of tissue oxygen delivery

It has been seen that in children, unlike adults, oxygen delivery and not oxygen

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extraction is the major determinant of oxygen consumption and attainment of therapeutic oxygen consumption goal of *200 ml/min/m²* has been found to be associated with improved outcome.[12] As shock progresses or increases in severity, perfusion pressure is reduced below the ability of the organ to maintain blood flow. This decrease in oxygen delivery is associated with a decrease in cellular partial pressure of oxygen. When PO_2 falls below critical levels, oxidative phosphorylation comes to a halt and there is a shift from aerobic to anaerobic metabolism resulting in a rise in cellular and blood lactate concentration and a decrease in ATP synthesis. During this stage of shock, which occurs early in the course, *oxygen extraction* increases and this is reflected in the form of a low SVO2 (mixed venous oxygen saturation) thus implying more oxygen being extracted from the blood to combat the tissue hypoxia. It is at this stage that interventions to improve oxygen delivery by improving either the *oxygen content* or *cardiac* output might be helpful. Oxygen content can be improved by correcting anemia and/or providing 100% oxygen to the child with shock. [3, 10,11]

Factors affecting cardiac output

The cardiac output is a product of stroke volume and heart rate (CO = SV x HR). The relative ability of infants and children to augment cardiac output through increased heart rate is limited by their preexisting elevated heart rate, which limits proportionate increase in heart rate without compromising diastolic filling time. Also, the increased connective tissue content of the infant's heart and decreased actin and myosin content of the infant's heart limit the potential for acute ventricular dilatation. Thus, the other option is to increase the stroke volume (SV). SV is dependent on the preload, contractility and after load. [3, 10, 11]

The first step in the management of shock is to ensure adequate preload or end-diastolic volume. According to *Frank Starling* phenomenon, ventricular contraction and measures to improve the same will be effective only if the preload is adequate. In every stage of shock, therefore, optimal preload should be ensured even after starting measures to improve the contractility and afterload.

After ensuring optimal preload, we can target either the contractility (by using inotropic agents) or the afterload (by using vasodilators/vasopressors) depending on the type of shock. The perfusion pressure is dependent on both cardiac output and systemic vascular resistance (SVR) or the afterload. It should, however, be noted that an excessive increase in SVR might decrease the cardiac output (as in cold shock) and thereby the perfusion pressure. In such instances, one might have to use either a vasodilator and/or an inotrope to maintain the cardiac output. [1,3,10,11]

Contrary to the adult experience, low cardiac output and not low systemic vascular resistance was associated with increased mortality in pediatric septic shock. Attainment of the therapeutic goal of a cardiac index (CI) of 3.3-6.0 L/min/m² was associated with improved survival in these children.[13]

The above physiologic principles are common to all the types of shock whether it is septic, cardiogenic, obstructive or hypovolemic and form the basis for treatment.[10,11]

Concept of mixed venous oxygen saturation (SVO2)

Having understood the relation between oxygen content and delivery, we need to look at the relation between oxygen delivery and consumption too, as the concept of early goal directed therapy (EGDT) for management of septic shock stems from these physiological principles. [14] In this context, mixed venous oxygen saturation (measured at the level of pulmonary artery) emerges as a useful tool in assessing the relation between oxygen consumption and oxygen delivery (VO2 – DO2). According to Fick's principle, VO2 = CO x (CaO2 –CVO2), where CVO2 = mixed venous blood oxygen content. As with the oxygen content in the arterial blood, mixed venous blood oxygen content is dependent on the mixed venous saturation (SVO2), cardiac output, and amount of hemoglobin. SVO2 would decrease with one or more of the following pathologies: hypoxemia, increased

oxygen consumption or reduction in cardiac output. [10,11]

Normally, SVO2 is between 65-77% as the oxygen extraction is 20-30%. In shock, with decreased oxygen delivery to the tissues, the oxygen extraction at the tissue level increases. This will decrease the SVO2. In late stages of shock, oxygen delivery is compromised to such an extent that oxygen extraction ratio increases to 60%. At this point, cardiac output will have to increase to compensate for the decrease in arterial oxygen content; otherwise, SVO2 will decrease to 40%. At 40% SVO2, there is an imbalance between arterial oxygen supply and oxygen demand which inevitably leads to sever tissue hypoxia. Indeed, in patients with septic shock, even a decrease in SVO2 of 5% from its normal value (65-77%) represents a significant fall in tissue oxygen delivery and /or an increase in oxygen demand. [10] Since SVO2 gives an indirect measurement of tissue perfusion in the early stages of shock, it is being used as one of the resuscitation end points in the management protocol of septic shock.[1,10,14] However, owing to the need for pulmonary catheterization to measure SVO2, which is neither practical nor feasible in most centers, the concept of superior venacaval saturation (SCVO2) came into existence. The advantage of determining SCVO2 over SVO2 is that it requires the insertion of a standard central venous catheter. It can be measured continuously or intermittently.[15] However, whether measurement of SCVO2 is a good surrogate for measurement of SVO2 is still not clear. The absolute values of SCVO2 are almost always higher than that of SVO2 and the two parameters track one another closely over a range of hemodynamic status.[16] Also, one has to bear in mind that femoral central venous oxygen saturation which reflects oxygen consumption of the lower limbs and intra abdominal organs cannot be substituted for subclavian/internal jugular central venous oxygen saturation as the brain is the most important organ in our body and we are more interested in the oxygen consumption of the brain which is reflected in the saturation of the superior vena cava. [17]

Hemodynamics in pediatric septic shock

Septic shock in children is most commonly associated with severe hypovolemia. More often, this is only relative hypovolemia secondary to maldistribution of cardiac output. Thus it is imperative to have an adequate fluid resuscitation to ensure the effective preload to the heart. Children frequently respond well to aggressive volume resuscitation; however, the hemodynamic response of children who are fluid resuscitated seems diverse compared with adults. [3,13]

Ceneviva et al. described 50 children with fluid-refractory (>60 ml/kg in the first hour), dopamine-resistant shock. The majority (58%) showed a low cardiac output and high systemic vascular resistance state, and only 22% had low cardiac output and low vascular resistance. Hemodynamic states frequently progressed and changed during the first 48 hrs. Persistent shock occurred in 33% of the patients. There was a significant decrease in cardiac function over time, requiring addition of inotropes and vasodilators. Although decreasing cardiac function accounted for the majority of patients with persistent shock, some showed a complete change from a low output state to a high output and low systemic vascular resistance state.

Inotropes, vasopressors, and vasodilators were directed to maintain normal Cardiac Index (CI) and systemic vascular resistance in the patients. Attainment of the therapeutic goal of a CI of 3.3-6.0 L/min/m^2 was associated with improved survival. Thus it is clear from the above study that the hemodynamic presentation in children with septic shock may be heterogeneous and change over time and therefore constant monitoring of these children with changes in therapy as required is imperative for better outcome. [13]

Clinical features and laboratory markers of shock

The clinical features of shock in children can be grouped into two types, namely cold shock and warm shock (see Table 1). [1,3,9] It is important to differentiate between the two types, as not only the hemodynamics but also the choice of vasoactive agents differs in these

two types. One has to be careful in chosing the vasoactive agent in either of these types, as use of an inappropriate vasoactive agent may prove to be detrimental and cause more harm than good. Also, one has to bear in mind that the hemodynamics in children with septic shock keep changing with time and therefore only continuous monitoring of the clinical signs will help in keeping pace with these changes and provide scope for revisions in fluid and Vasoactive therapy.

Apart from abnormal values of superior vena caval oxygen saturation as mentioned above, serial base deficit and blood lactate values are important markers of systemic hypoperfusion and can be used as therapeutic end points in the monitoring and treatment of shock. [10,11]

Table 1. Clinical and Laboratory features of 'Cold shock' and 'Warm shock

Clinical / Lab parameters	Cold shock	Warm shock
1. Tachycardia	Present	Present
2. Pulses	Feeble	Bounding
3. Blood pressure	Normal or decreased (in late stages)	Normal or decreased (in late stages) with wide pulse pressure
4. Peripheries	Cool, mottled	Warm
5. CRT	>2 secs	Flush, <2 secs
6. Urine output	Decreased	Decreased
7. Sensorium	Altered	Altered
8. Urine Output	Decreased	Decreased
9. Scvo2	<70%	Usually > 70%
10. Lactate/ Base Deficit	Increased	Increased

MANAGEMENT OF SHOCK

The management of shock is aimed at restoration of microcirculation and improving organ tissue perfusion which can be achieved by early recognition, timely intervention with fluid therapy and considering vasoactive agents in fluid resistant shock. Inadequate early resuscitation results in multiple organ system failure and in death days to weeks after the initial presentation.[1] This has been confirmed by a recent meta-analysis which suggested that aggressive resuscitation efforts started early (before the onset of organ failure) may prove more beneficial than resuscitation carried out after the establishment of organ failure.[18] The management guidelines for septic shock in adults and children have been laid down by the Surviving Sepsis Campaign Committee which is a time bound guideline based on the concept of Early Goal Directed Therapy (EGDT). [14]

Early goal-directed therapy (EGDT) is a research innovation that uses a set of clinical and laboratory parameters including measurement of superior vena caval oxygen saturation lactate and base deficit to titrate therapeutic end points in patients with septic shock. Thus, EGDT is simply a protocol derived from components that have long been recommended as standard care for the septic patient in the setting of the Emergency and ICU. In a study of 263 adult patients, EGDT was associated with a 16% absolute risk reduction for in-hospital mortality, which to date is the largest mortality benefit demonstrated in septic shock.[14] The EGDT protocol has been modified and advocated for pediatric septic shock in the "surviving sepsis campaign guidelines" with similar resuscitation end points like ScvO2 >70 % ,decreased lactate, urine output > 1ml/kg/hr, CRT<2 sec, normal mental status and normal pulses with no difference between peripheral and central pulses. [9]

'SURVIVING SEPSIS CAMPAIGN' GUIDELINES

In 2004, an international group of experts in the diagnosis and management of sepsis representing 11 organizations published internationally accepted guidelines for management of patients with severe sepsis (*Surviving Sepsis Campaign Guidelines*).[9] The 2004 guidelines had been recently updated in January 2008 by incorporating the available evidence in the preceding 3 years. Also, a new evidence-based methodology system had been used for assessing the quality of evidence and strength of recommendations. These guidelines cover almost all aspects of management of children with severe sepsis and septic shock like early and aggressive resuscitation of septic shock with fluids and vasoactive agents, administration of adjuvant therapy, source control measures, and management of other organ dysfunction. The guidelines emphasize the importance of early recognition of shock and have therefore drawn out an action plan which is time bound from the time of recognition of shock. [9]

Before proceeding with the management guidelines, we need to understand the pharmacokinetic properties and role of various vasoactive agents mentioned in the guideline at different stages. This information would also be used as reference for the clinical questions to be discussed in the next issue (See Table 2). [1, 3]

Table 2: Vasoactive agents used in various types of shock

	Inotrope	Vasopressor	Vasodilator
Mechanism of action	Increases contractility and / or heart rate	Elevate SVR by increasing the tone of arterial circulation	Decrease arterial resistance, resulting in decreased afterload and increased cardiac output without affecting contractility
Indication	Cold shock with normal blood pressure, when blood pressure is low use in combination with a vasopressor	Warm shock with low blood pressure, cold shock with low blood pressure (used in combination with an inotrope),	Diminished peripheral perfusion with normal blood pressure, low cardiac output states
Examples	Dopamine, dobutamine, epinephrine, milrinone, *digoxin**,	Dopamine, epinephrine, *vasopressin#*, *norepinephrine#*,	Dobutamine, *Nitrogycerine$*, *nitroprussides$*, milrinone lactate$,

*Purely inotropic/chronotropic action; #Purely pressor effect;$ Purely vasodilator effect

Surviving sepsis campaign guidelines for the management of septic shock in children

According to the guideline, when a child presents with septic shock to the emergency/ ICU aggressive fluid resuscitation with crystalloids/colloids of up to 60 ml/kg as boluses of 20ml/kg is to be pushed by IV route over the first 15 minutes to achieve desired heart rates, and blood pressure. This strategy is a relatively inexpensive and feasible intervention, but underutilized. A possibility of fluid overload should be kept in mind specifically in malnourished children. This may however be overcome by intense clinical monitoring.

If a patient does not respond to aggressive fluid therapy (fluid refractory shock), central venous line should be placed and vasoactive drugs should be started. Dopamine is recommended as the first line agent in children who are in shock despite fluid resuscitation (60 ml/kg). Dobutamine is to be used as the

first choice in children with normal BP and low cardiac output (cold shock) as indicated by poor peripheral perfusion.

It is desirable that all children with septic shock be managed in intensive care setting. However, given the scarcity of ICU beds, the emergency physicians should be well equipped with the knowledge and skills required to resuscitate such children in the emergency department.

In case of shock refractory to dopamine or dobutamine, epinephrine or nor-epinephrine should be used depending on whether the child has cold shock or warm shock, respectively. If there is no response to the above catecholamines then the $ScvO_2$ (requires central venous catheter placement in the superior vena cava) should be monitored apart from clinical and hemodynamic variables and vasodilators/ Phosphodiesterase (PDE) inhibitors could be added in children with normal blood pressure and cold shock with $ScvO_2$<70%. In children with low blood pressure either epinephrine or nor-epinephrine could be titrated depending on whether the child has cold shock or warm shock.

Use of adjuvant therapy

Steroids are to be used only in children with suspected or proven adrenal insufficiency. Pediatric data shows high prevalence of adrenal insufficiency in children with septic shock, especially catecholamine refractory shock. [19] As cortisol estimation results may take time; it may be appropriate to take a sample for the assay, start hydrocortisone and decide about its continuation after assessing response and considering the results of the assay.

Based on a recent large trial in children which did not demonstrate any effect of recombinant activated protein C, it can be concluded that there is no role of recombinant activated protein C. [20] There are some data to suggest improved survival and reduced hospital stay with intravenous immunoglobulin (IVIG) in children with severe sepsis and septic shock. As the data are limited, IVIG may be considered in carefully selected group of children with severe sepsis. [21]

Administration of broad-spectrum antibiotics in parallel with fluid resuscitation to cover for the likely pathogens (including gram positive and gram negative) within 1 hr of diagnosis of septic shock / severe sepsis as well as reassessment of antibiotic therapy after microbiologic data is available, to narrow coverage, when appropriate is recommended . The choice may vary from unit to unit based on the sensitivity patterns. It is desirable to have surveillance data on microorganisms and their sensitivity.

Use of lung protective ventilation strategy like low tidal volume, use of positive end-expiratory pressure (PEEP) and limitation of inspiratory plateau pressure to prevent lung injury and/or limit injury in acute respiratory distress syndrome (ARDS) are other measures to improve outcome in these patients. [22] An important aspect is use of agents for sedation/ analgesia after careful selection; one should avoid etomidate and propofol for fear of adrenal suppression and metabolic acidosis respectively. [9]

The evidence for beneficial effects of strict glycemic control is not very strong. However it is important to avoid hypoglycemia by proper monitoring.[23] Routine stress ulcer prophylaxis is not recommended.[24] Prophylaxis for deep vein thrombosis (DVT) may be useful specifically in post pubertal children with severe sepsis.[25] The recommendations of the committee are largely based on studies from developed countries where there are resources to do ECMO and pulmonary artery catheterization in PICU patients.

The guidelines discussed above cannot be universally applied to PICU/emergency departments from developing countries as these resources are not uniformly available across the country. Therefore, a modified algorithm for the management of septic shock in resource restricted settings is proposed (see

In conclusion, the dynamics of septic shock change with time and therefore early recognition, timely intervention and close monitoring are imperative for improving the mortality and morbidity associated with this condition. While managing these children, the

important physiologic principles of oxygen delivery, cardiac output and oxygen consumption should be kept in mind and therapy should be titrated to optimize these values. In the subsequent issue, we shall be looking at the evidence behind the recommended vasoactive agents used in septic shock.

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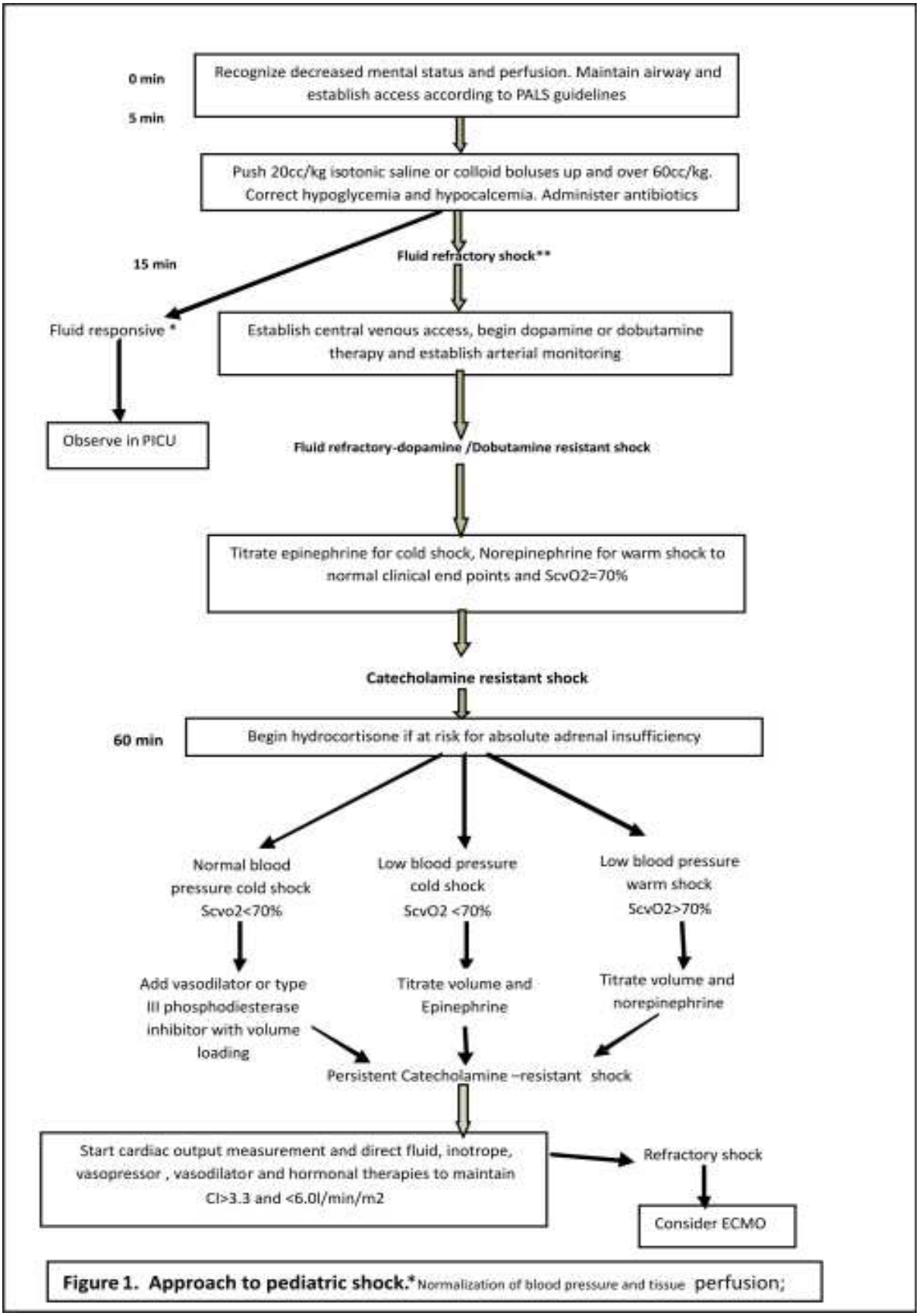
Editor's note

In the second part in the series on 'Management of Pediatric/Neonatal emergencies' we would be dealing with one of the most commonly encountered clinical conditions in pediatric emergency and intensive care units – septic shock . Since it is important to understand the physiologic principles involved in the management of septic shock before embarking upon evidence based management, we have restricted the discussion to physiologic principles of shock and standard guidelines for management of this dreaded condition in this issue. The clinical questions would be discussed in the forthcoming issues.

Figure 2. Approach to pediatric shock in resource restricted settings. *Normalization of blood pressure and tissue perfusion;hypotension, abnormal capillary refill or extremity coolness. Adapted from Surviving Sepsis Campaign**



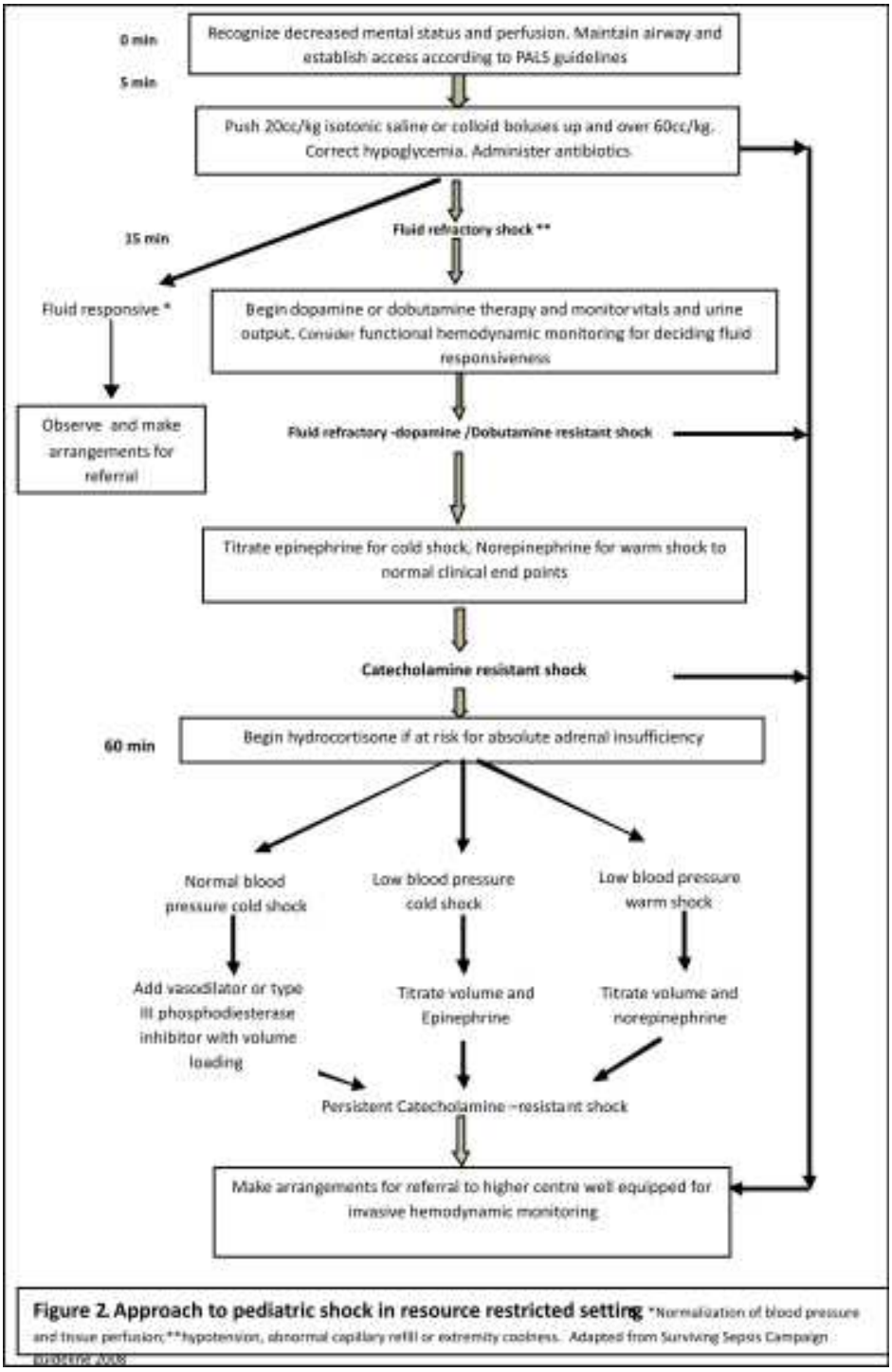


Figure 2. Approach to pediatric shock in resource restricted setting *Normalization of blood pressure and tissue perfusion;**hypotension, abnormal capillary refill or extremity coolness. Adapted from Surviving Sepsis Campaign guideline 2008

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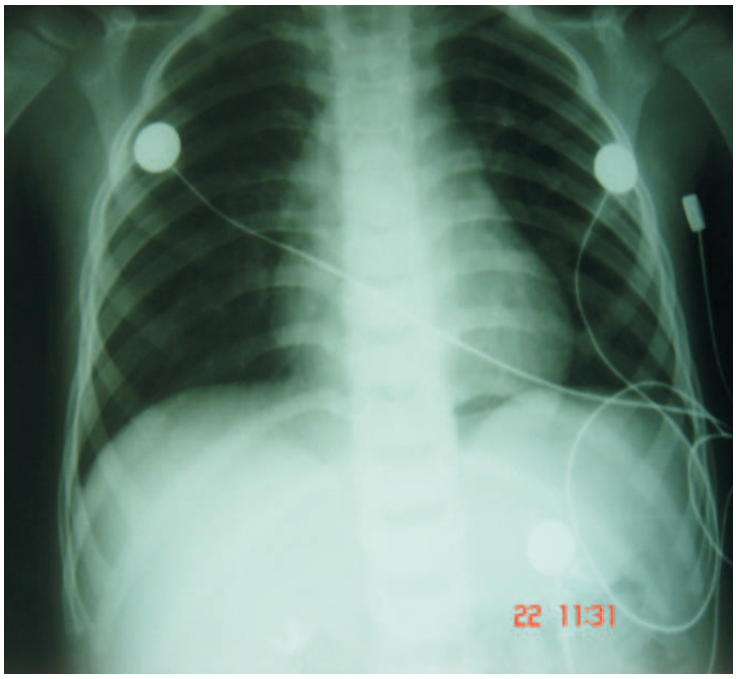
Mirages and images

Adhisivam

Case 1

A five year old boy was found to have sudden altered sensorium at home and rushed to the ER at 2 pm. This developmentally normal boy had history of 2 episodes of seizures 2 weeks earlier and was not on any anticonvulsant. On examination, he was afebrile, responding to painful stimuli and had no meningeal signs. So, a diagnosis of Seizure disorder with post ictal state was considered. However, he was tachypnoeic and had bilateral wheeze. Aspiration pneumonitis was suspected and a CXR was requested.

Figure 1



The lung fields were clear in the CXR. However, suspicious discrete radio opaque shadows were noted in the upper abdomen (red arrows). With the history of sudden onset altered sensorium without fever and radio opaque shadows, pica/poisoning was considered as a probable cause of the altered sensorium. To see the abdomen further a XRay abdomen was taken (Fig.3) which revealed central opaque density in the pelvis (urinary bladder).

On further questioning, the mother revealed that child had undergone a CT imaging of the brain in the morning for seizure disorder and the contrast given during the procedure was

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Figure 2

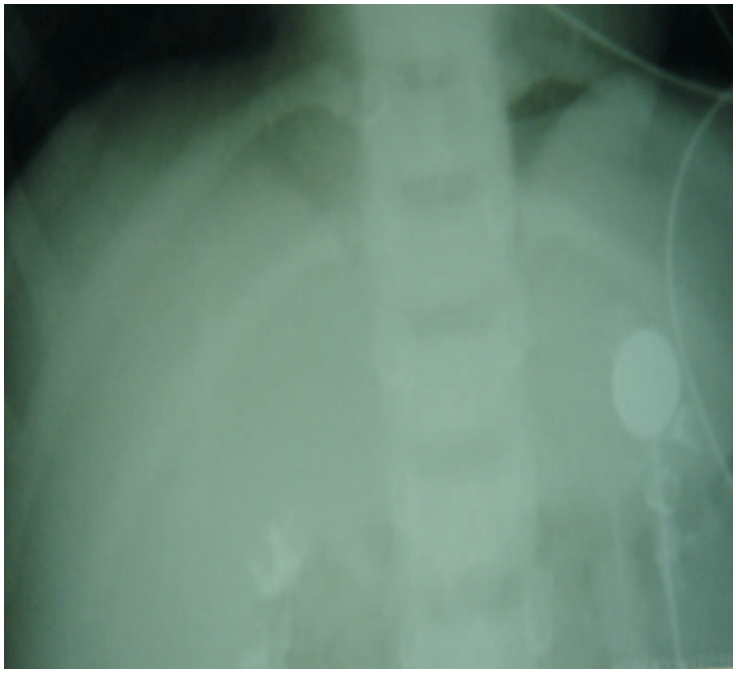
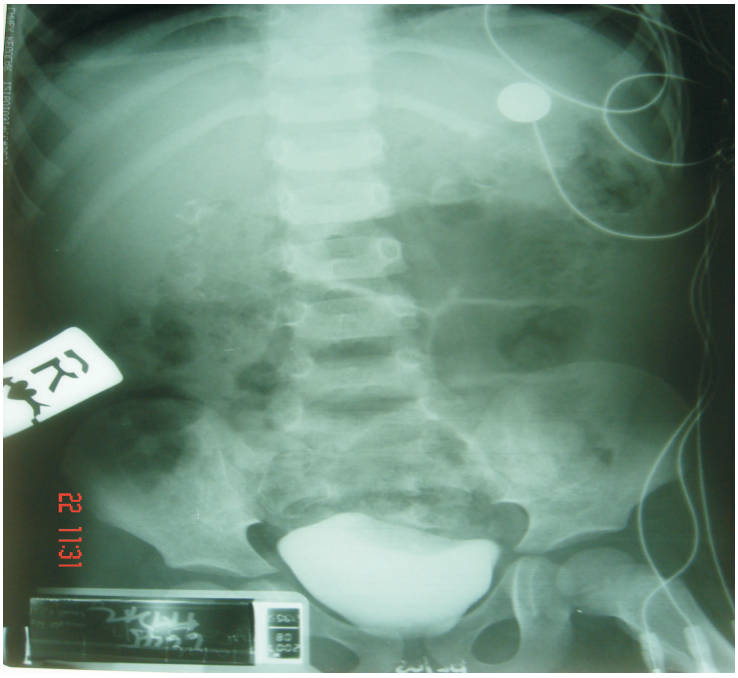


Figure 3



being excreted through the kidneys into the urinary bladder. When we asked the mother why she did not part with the information, she replied "You never asked for it". The boy was kept under observation for a day and discharged on oral anticonvulsants.

LESSON1 – WHERE THE PIECES OF THE JIGSAW ARE NOT FITTING, RETAKE THE HISTORY

Case 2

A six year old mentally retarded boy presented to the ER with respiratory distress.

He was a known wheezer and has had similar exacerbations earlier. On examination, he was tachypnoeic and dyspnoeic. Auscultation of his chest revealed bilateral rhonchi and decreased breath sounds on the left side. A diagnosis of Bronchial Asthma with acute exacerbation was considered. Despite continuous nebulisation and IV steroids, his respiratory distress persisted and hence a CXR was requested.

Figure 4

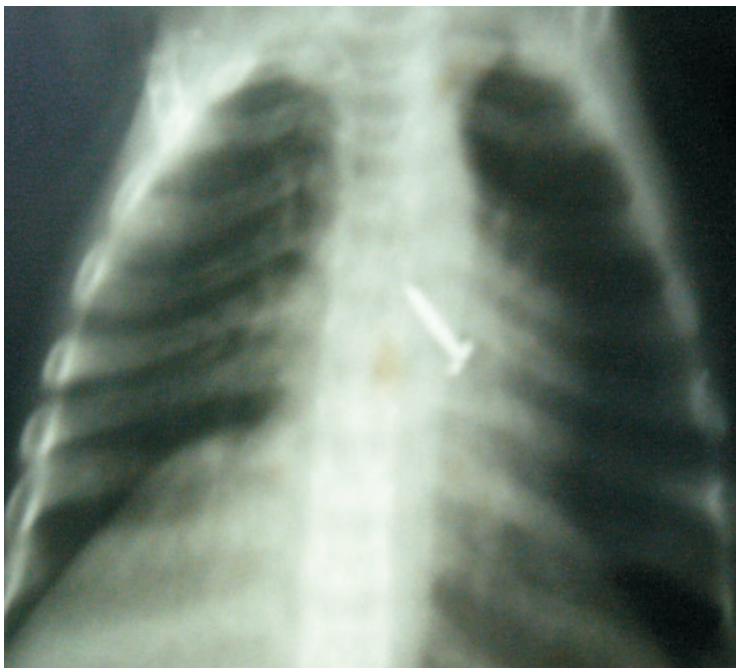
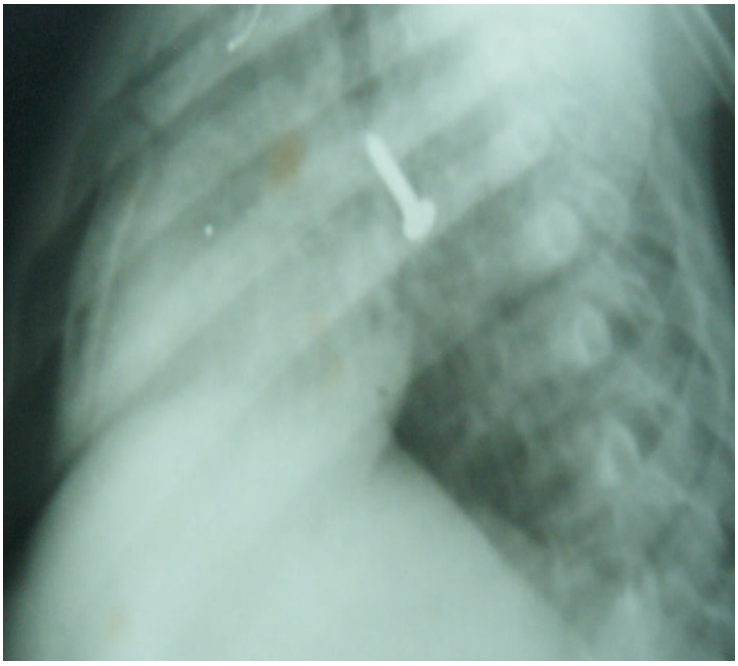


Figure 5



His Chest X-ray (fig.4 & 5) showed a radio opaque foreign body in the left main bronchus and obstructive emphysema on the same side. An emergency bronchoscopy (rigid) was done and the foreign body, a metal screw measuring 2 cm was removed after which his respiratory distress settled. In this case, the child's neurological status probably contributed to the aspiration.

Lesson 2 – All that wheezes is not asthma

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Journey of Pediatrics

The journey of paediatrics starts from Vedas time. All ancient works has proven that the concept of paediatrics was there. But because of lack of documentation in our country,we can not prove it. That's why we consider paediatrics as a young faculty medical branch.

In ancient India -6th century Kshyapa rishi and his student Jeevaka has done pioneering work on children care and childhood diseases. The first manuscript on the management of children were written in their book of Kasha yap samhita. Writings of these book are still useful in modern concepts of child health.[1]

After Kashia and Jeevaka in 800-400 B.C. Sushruta has done written many aspects of child rearing such as infant feeding, viral fever,liver diseases etc. He is called as INDIAN HIPPOCRATE.[2,3]

In 300 B.C. **Charka** was the great contributor in Ayurveda. He has written CHARAKSAMHITA. He was the first physician to demonstrate the concept of digestion, immunity, anatomy and genetics.[2,3]

In 460 B.C.-370 B.C.an ancient Greek physician **HIPPOCRATE** has worked extensively in the field of medicine. Regarding pediatrics, clubbing of fingers in a patient with Eisenmengers syndrome, first time described

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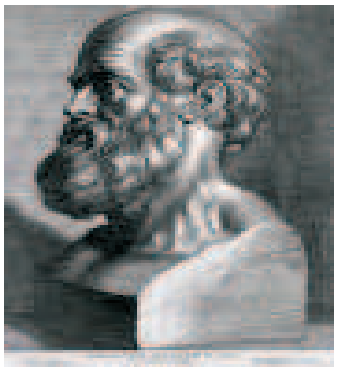
by Hippocrates, so this clubbing is also known as "Hippocratic fingers. Hippocrates and his followers were first to describe many diseases and medical conditions in children like cyanotic heart disease. Hippocrates was also the first physician to describe Hippocratic face. He had devoted a great part of his life to treatise to children and made significant observations found in children.[4]



Galen (A.D.129-217) from Bergama,now a days called as Turkey, was a prenhysicien,who studied paediatrics extensively and wrote on care of infant and child.[5]

Muhammad bin Zakariya razi-(Rhazes/ Rasis)- He was among the first to distinguish one contagious disease from another, particularly, smallpox and measles.

He was the chief physician of Rey and Baghdad hospitals. Razi invented what today is known as rubbing alcohol. He is also called as the father of pediatrics.[6]

Soraneus (Second century A.D.) from Greece, He wrote the first known manuscript devoted to pediatrics. He described fingernail test for breast milk quality- if the droplet clings to the nail, it contains sufficient fat, if not, it is watery.[7]

First printed book on pediatrics was written by Italian writer Bagllerder - "Little Book on diseases in children."[1472]

First English book on pediatrics written by-Thomas phaer -"Book of children",in A.D.-1545.

Hieronymus wrote the first important printed book about children in 1583.

Abraham Jacobi - (May 6, 1830 - July 10, 1919)-He was the pioneer of pediatrics in America. He received M.D. degree in 1851 and started job in New York Medical College, as a professor of childhood diseases. From 1867 to 1870, he was chair of the medical department of the City University of New York. He taught at Columbia University from 1870 to 1902. He later moved to Mount Sinai Hospital, where he established the first Department of Pediatrics at a general hospital. He was a pioneer of pediatrics, opening the first children's clinic in the United States.[8]

Historically the first pediatric hospital in the world

Hospital Necker - Enfants Malades (*Necker Hospital - Hospital for sick children*)

Is a French teaching hospital, located in Paris, France.

First pediatric hospital in London

Great Ormond Street Hospital for Children: A medical institution specializing in the care of children. It was founded in London in 1852 as the Hospital for Sick Children, making it the first hospital providing in-patient beds specifically for children in the English-speaking world.

One of the largest and oldest children's hospitals in the world

Children's Hospital of Philadelphia: This has been ranked as the best children's hospital in the United States. A Philadelphia physician, Dr. Francis West Lewis, inspired by a visit to the new Great Ormond Street Hospital for Sick Children in London (founded 1852), along with Drs. T. Hewson Bache and R.A.F. Penrose to found the first children's hospital in North America.

First children's hospital in India

Pediatrics made a beginning in Mumbai in 1928, when **Dr George Coelho**, rightly called the Father of Indian Pediatrics, became the Superintendent of the BJ Hospital for Children -the first children's hospital in India. He remained the head of the department of Pediatrics till 1953. In 1929, Bai Jerbai Wadia Hospital for Children became a separate independent children's hospital.

Dr George Coelho started independent research and services in 1928. The postgraduate course for diploma in child health was started at **BJ Hospital and Bai Jeerbai Wadia hospital** for children in 1944 and the University of Bombay in 1946. Many of the senior pediatricians of today in the country worked at the BJ Hospital for children under the leadership of Dr George Coelho. He edited the Indian Journal of Child Health from 1952 to 1959.

In India, prior to 1948, there was no pediatric department as such and the children were treated by general physicians. In 1948, the first pediatric department of Tamilndau was created in the Government General Hospital, Madras by **Dr.S.T.Achar**. He was appointed as Professor of Pediatrics of Madras Medical College. Initially this hospital has only 28 beds. Since 1949 department started attracting a number of medical graduates. They joined the Pediatric Department as voluntary postgraduates in order to get training in Pediatrics – first of its kind in our country.[9]

DR.K.C. CHAUDHARI - From Calcutta, has established a private institute of child health in Calcutta. Then he became the first director of same institute. He founded the first independent pediatrics journel -THE INDIAN JOURNEL OF PAEDIATRICS, in Calcutta in 1933. He also founded INDIAN PAEDIATRICS SOCIETY in 1946.[10]

The Association of Pediatrics of India started in 1950 in Bombay by Dr. George Coelho. Dr. Chaudhuri on the other hand started -The Indian Pediatric Society.

A joint committee was set up to formulate proposals to achieve merging of these to associations. The members of the committee were Dr. S.K. Bose, Dr. H. Chandra, Dr SP Ghosal, Dr. S.S. Manchanda, Dr. B.D. Patel, Dr. P. Tirumala Rao, Dr. Shantilal C. Seth, Dr. P.N. Taneja, Dr. P.M. Udani and Dr. J.K.G. Webb. The committee held its first meeting at Hyderabad in March 1962. Dr Sisir K Bose was elected its Convener. The committee laid down the principles on which the new body to be called the "Indian Academy of Pediatrics" would be constituted. The Secretaries of the two existing bodies, Dr. S.P. Ghosal and Dr. B.D. Patel were called upon to draw detailed proposals regarding the constitution of the proposed "**Indian Academy of Pediatrics".**

The joint committee held its second meeting on the eve of the joint Hyderabad conference of the two bodies in 1963. .

The Indian Pediatric Society and the Association of Pediatricians of India then jointly decided to form the Indian Academy of Pediatrics as the single representative body of Pediatricians of India and the first National Conference of the Indian Academy of Pediatrics was held in Pune in 1964. The official journal of the IAP - Indian Pediatrics, incorporated the Indian Journal of Child Health and the Journal of the Indian Pediatric Society; commenced publication in January 1964 from Calcutta. The central office of the Indian Academy of Pediatrics was established in Mumbai.[11]

Indian Academy of Pediatrics

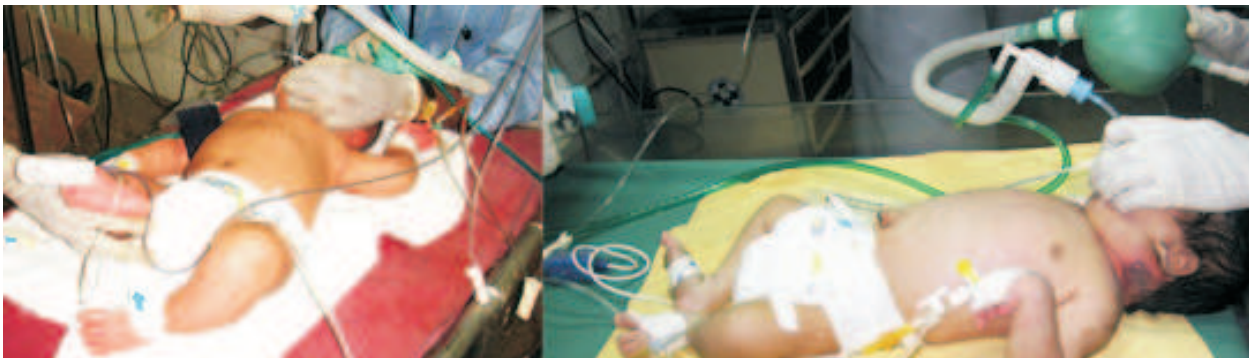
The Indian Academy of Pediatrics was established in 1962, in Patna, Bihar, with less than 100 pediatricians as its members. It has State, District, and City level branch.

The IAP is the unique association of pediatricians in India. The association has been able to maintain unity among its members.

One of the major activities undertaken by the IAP since its inception has been to organize Continuing Medical Education (CME) programs by holding conferences, symposia, lectures and other meets all over the country.

IAP head office is in Mumbai while Delhi is the seat of its official publication - Indian Pediatrics, an indexed journal. A more recent journal - Practical Pediatrics - - is published from Chennai.[11]

Emergency paediatrics



Save lives in golden hours

This very important sentence regarding emergencies in any age group. The children are always in top priorities in emergencies. Unfortunately there is no separate treating department or teaching curriculum in pediatrics. Since ancient time the pediatric emergencies are changing or sometimes added like-home deliveries, tetanus, asphyxia, drowning, accidental poisoning, roadside accidents, infectious diseases, suicides, burns etc. Since now a days because of C.M.E.s, Wokshops, informative Journals most of the pediatricians are updated with knowledge of EMERGENCY PAEDIATRICS. But as such it is the new specialty Medical Council of India, should give emphasis on such subject to undergraduates as well as postgraduate student. EMERGENCY PAEDIATRICS is the emerging branch of medical field not only in India but all over the world.[12]

Pediatrics as a separate teaching subject

1948-First chair of pediatrics.

1955-Medical education conference recommended reconstructing pediatric sub.

1956-Recommended pediatrics as a separate subject.

1966-M.C.I. accepted pediatric as a separate teaching subject.

1976-M.C.I.-all universities-separate teaching subject.

1993-Paediatrics as separate teaching subject started.

Dr. Raghunandan V. Sanzgiri, along with Dr. Coelho, started the DCH course at the CPS

(1944) and later MD in Paediatrics at the University of Bombay. To generate and keep up the interest in Paediatrics, he started the programme of rotating clinical meetings in various hospitals in 1946 and these are being held to this day. He was the main force behind the 'Indian Journal of Child Health'. In 1963.

Harish Chandra organised the national conference which helped in the amalgamation of the two independent associations of Pediatricians mentioned above. He started the MD degree course at the Somalia University at 'Institute of Pediatrics', Niloufer Hospital, Hyderabad which was followed by postgraduate courses in Pediatric Surgery (1977).[11]

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