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Ventilator Associated Pneumonia in Pediatric ICU Prophylaxis and Treatment

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Abstract

In this review we discuss ventilator associated pneumonia in the pediatric ICU with possible preventive measures and treatments. The current opinion concerning causative agents and therapies is presented. The place of selective decontamination of the digestive tract, bed head lift as well as stress ulcer prophylaxis is reviewed.

Keywords: *Ventilator associated pneumonia, colonisation of hypopharynx, selective decontamination of the digestive tract, bed head lift*

Ventilator associated pneumonia is a common and serious complication in intubated patients. What is particular about them is that a series of anatomical and physiological barriers such as swallowing, cough, compromised ciliary clearance, which protect the lower airways are eliminated or bypassed. Most of the patients have compromised immune response after trauma, surgery or primary respiratory failure[1,2]. Also mechanical ventilation gasses are not always properly heated and humidified. This leads to inspissation and drying of secretions and atelectasis.

It is notable that in more than ⅔ of cases the causing organisms are part of the resident flora of the pharynx of the patient[3-5]. Usually these are opportunistic Gram positive organisms. Reduced or absent swallowing leads to accumulation of secretions in the hypopharynx, which sooner or later find their way to the lower airway. This is much easier in cuffless tubes that are often utilised in children but also happens to tubes with cuffs. Experiments with colourants demonstrate this mechanism very clearly[6].

The second most common group of causative organisms are bacteria who colonise the pharynx secondarily. Again they usually come from the patient himself. Patients in the PICU very often have compromised peristalsis for various reasons. This happens even to children who don't have abdominal surgery. Lack of adequate peristalsis leads to gut flora ascending to the hypopharynx. Peristalsis is a key factor for the maintenance of particular flora in every region of the gut. Another key protective factor is the acidity of the stomach [7,8]. Unfortunately PICU patients are prone to stress ulcer development and too often receive medication to increase stomach pH. When this barrier is removed there is nothing that can stop the gut flora from getting to the hypopharynx. Usually these are Enterococci and Escherichia coli etc.[9,10,11] These bacteria colonise the hypopharynx and then descend into the trachea and lung. It should be noted that even these microbes are susceptible to most antibiotics as they come from the patient and not the hospital.

The third scenario includes the feared hospital germs who are usually Gram negative and include Acinetobacter, Serratia, Klebsiella, Proteus, Enterobacter, Pseudomonas, Moraxela[12]. Often these bacteria are only sensitive to Colisthimethate and Tigecycline (which has limited use in children). Hospital germs colonise the patient before they infect him. The least common mechanism is direct inoculation of a hospital microbe into a sterile site when medical personnel disregard hygiene measures. Hand hygiene is extremely important but it leads to contamination of the patient first, then to overgrowth and colonization and lastly infection. Monitoring pharyngeal and anal microbiology twice weekly gives a very good clue to the current flora of the patient and what to expect from the trachea and other sterile sites [13-15].

Another prophylactic measure that has been praised and criticized for the last 30 years is selective digestive tract decontamination or selective digestive tract decontamination (SDD). It has been widely used in Europe and less in North America. The idea behind this is to clear the digestive tract of pathogens while maintaining the resident flora (which mainly consists of anaerobes like Bacteroides Fragilis). Non-absorbable agents that are active against hospital germs are needed. The most popular combination of antimicrobials includes Tobramicin, Colisthimethate and Amphotericin B. Tobramicin is chosen for its wide spectrum against Gram negatives and good Antipseudomonal activity. Colistimethate is active against most multidrug resistant Gram negative organisms and is poorly absorbed in the gut. It is deactivated to a large extent by dietary fiber and stool. Amphotericin B is a wide spectrum antifungal agent which is highly toxic parenterally, but not enterally. Vancomycin is sometimes added to this combination, but it can select resistant Enterococci and is not too selective for resident bacteria. That's why it is not part of the standard protocol. [16-18]

SDD requires treatment of the mouth and pharynx with a gel containing the aforementioned antibiotics several times daily as well as a liquid mix instilled into the stomach. Monitoring of pharyngeal and anal flora is done twice weekly.[18,19] The main argument of the opponents of SDD is the development of resistance. There are several major studies that fail to demonstrate increased resistance of bacteria, but show a reduced incidence of ventilator associated pneumonia. Another shortcoming of SDD is the need to prepare the antimicrobial mixtures in the hospital pharmacy.

Other approaches that have proved useful in reducing VAPs and have shown benefit in studies are: bed head elevation to 30-45°, daily sedation and relaxation holidays, careful use of ulcer prophylaxis and use of modified tubes.

Head Elevation

Head elevation is highly recommended especially in patients who are fed enterally and risk reflux which is facilitated by the nasogastric tube itself. Some studies show a reduction of VAP by up to 70% by this maneuver.[20,21]

Avoidance of muscle relaxation and sedation holidays lead to faster extubation and avoidance of complications.

Stress Ulcer Prophylaxis

Use of H2 blockers and PPIs often increases stomach pH above 4 which leads to overgrowth of bacteria by eliminating a key protective mechanism[22]. Sucralfate has a smaller protective effect but it does not affect pH and is theoretically preferable in stress ulcer and VAP prophylaxis. Unfortunately its use in children is off label[24].

Modified Endotracheal Tubes

As the major mechanism for contamination of the trachea is by hypopharyngeal secretions special endotracheal tubes with a second small channel have been developed which allow for continuous suction of these secretions. Studies have shown a reduction in VAPs by up to 50% with such tubes. As they are bulkier than regular tubes, sizes are only available for children over 40 kg. [25]

Silver impregnated endotracheal tubes also show good results in many studies but their effect is limited to the first few days, after which their antimicrobial activity is reduced by the accumulation of secretions. Many bacteria also produce biofilms which significantly reduce Silver ion activity. Silver coated/impregnated tubes are also much more expensive than regular ones.

Probiotics have shown some benefit in studies, but conclusive evidence is still lacking. What is more important bacterial strains used in probiotics have been shown to cause bacteremia and even lethal infections in immunocompromised ICU patients. This has led to some producers explicitly warning against the use of these products in ICU patients. [26]

Chlorhexidine Mouthwash

Daily chlorhexidine mouth treatment and teeth care is very important, but one should have in mind that Chlorhexidin's effect is better on Gram positive organisms. [27]

Therapy

A key factor for the successful treatment of VAP as of all infectious disease is the good knowledge of local flora and good collaboration with the Microbiology department.

VAPs are twice as common in neonates and infants as compared to older children. The four most common causative agents are S.aureus, Pseudomonas aeruginosa, Klebsiella spp, Enterobacter spp followed

by Streptococcus pneumoniae and Escherichia coli. Patients who develop VAP within 48 hours of hospital admission have susceptible organisms.[28-29] Patients who have spent more time in the hospital or have been treated with antibiotics recently present with more resistant flora. In this group of patients a combination of glycopeptide plus carbapenem is a common empiric choice before narrow spectrum antibiotics can be suited to sensitivity testing.

The American Thoracic Society[7] recommends: the early use of wide spectrum antimicrobials, the use of two antipseudomonal drugs from different classes, when this germ is suspected; Linezolid is an alternative to Vancomycin in MRSA and is supposedly better for MRSA VAP; Colistimethate is a drug of choice in carbapenem resistant Acinetobacter; Inhaled Tobramicin and Colisthimetate have proven benefits.[30]

Children with chronic respiratory conditions or those with tracheostomies or some form of chronic ventilator use pose particular problems. More than 90 % of them present with Pseudomonas and 50% with MRSA.[31,32,33]

We present an infant patient that is illustrative to the Pediatric ICU setting.

The patient is admitted at 46 days age for the closure of a high ileal anus praeter which was opened immediately after birth because of a prenatal ileal perforation. The child has very poor weight gain because of the high derivation and soon after hospital admission his condition deteriorates and he is transferred to the PICU where he is intubated, and empirical Teicoplanin and Meropenem are commenced. Dopamine was also commenced. Surgery was postponed for over a month. This patient presented multiple risk factors for VAP: neonate, malnutrition status; early radical surgery and many hospitalizations from an early age. After the surgery the child was sent home 42 days after admission.

Fig 1. Depicts the clinical course of this patient. Vertical lines show dates of microbiology sampling and corresponding isolate.

The length of treatment with an antibiotic/Dopamine or ventilation correspond to the length of the horizontal bars. Dates are in two months. Curves represent levels of CRP, WBC and Plt numbers.

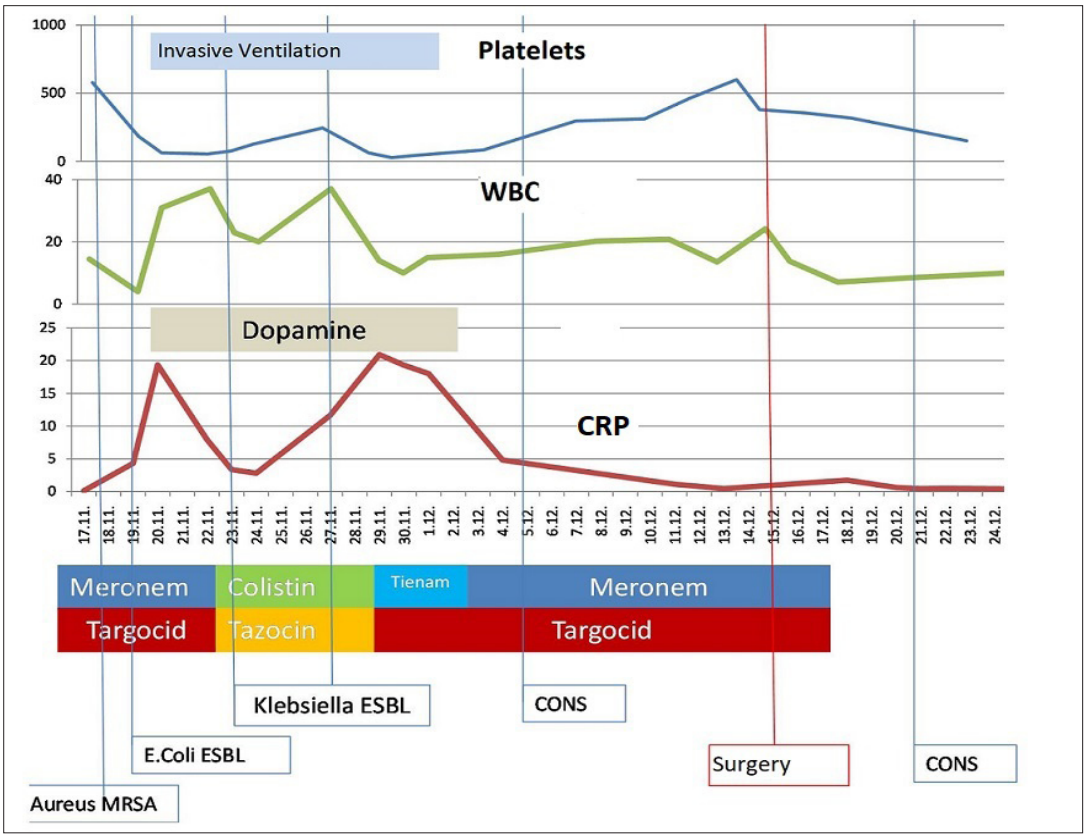

Fig1.

Fig2. *Microbial isolates and sensitivity*

Antimicrobial/ Isolate	E.coli ESBL	Klebsiella ESBL	Klebsiella ESBL MBL
Amoxiclav	R	R	R
Pipe/Tazo	S	S	R
Ampicillin/Sulbactam	R	R	R
Cefazolin	R	R	R
Cefuroxim	R	R	R
Cefotaxim	R	R	R
Ceftazidim	R	R	R
Cefepim	R	R	R
Meropenem	R	S	R
Imipenem	R	S	R
Gentamicin	R	R	R
Tobramicin	R	R	R
Amikacin	R	R	R
Ciprofloxacin	R	R	R
Biseptol	S	S	R
Levofloxacin	R	R	R

Conclusions

Ventilator associated pneumonia is a serious complication in PICU patients and is related to a number of risk factors. Some of these cannot be influenced: age; use of intubation, use of cuffed or uncuffed tube; prior hospitalization or antibiotics; nutritional and immune status. There are also a number of factors we can work on to prevent VAP: adequate hand hygiene between patients and strict asepsis for invasive procedures, bed head lift, avoidance of stomach pH altering agents, mouth hygiene with chlorhexidine, selective digestive tract decontamination, avoidance of relaxation and prolonged sedation, specialized intubation tubes in appropriate patients, knowledge of local pathogen sensitivity and adequate antimicrobial policy.

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