Ventilator associated pneumonia in major paediatric burns

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ABSTRACT

More than three-quarters of deaths related to major burns are a consequence of infection, which is frequently ventilator associated pneumonia (VAP). A retrospective study was performed, over a five-year period, of ventilated children with major burns.

92 patients were included in the study; their mean age was 3.5 years and their mean total body surface area burn was 30%. 62% of the patients sustained flame burns, and 31% scalds. The mean ICU stay was 10.6 days (range 2–61 days) and the mean ventilation time was 8.4 days (range 2–45 days). There were 59 documented episodes of pneumonia in 52 patients with a rate of 30 infections per 1000 ventilator days. Length of ventilation and the presence of inhalational injury correlate with the incidence of VAP. 17.4% of the patients died (n = 16); half of these deaths may be attributed directly to pneumonia.

Streptococcus pneumonia, Pseudomonas aeruginosa, Acinetobacter baumannii and Staphylococcus aureus were the most prominent aetiological organisms. Broncho-alveolar lavage was found to be more specific and sensitive at identifying the organism than other methods.

This study highlights the importance of implementing strictly enforced strategies for the prevention, detection and management of pneumonia in the presence of major burns.

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1. Background

Severe burns are one of the most devastating forms of trauma. In South Africa, burns are the third commonest external cause of fatal injuries up to the age of 18 years and the main cause under the age of 4 years. In the Cape Town region, at least six in 10 000 children are seriously burnt every year, and as many as 15 in 10 000 toddlers and infant [1,2].

The modern treatment of burns has become a logical exercise in resuscitation, early excision and skin grafting, infection control, wound care, pain relief, nutrition, and rehabilitation. There is widespread recognition that specialist burns units or centres deliver the most comprehensive care for these patients and as a result of these measures within this multidisciplinary environment, mortality and morbidity rates have declined significantly [3,4].
Major thermal injuries depress the immune system; three quarters of all severe burn related deaths are now a consequence of infection, most notably burn wound infections, sepsis, pneumonia and urinary tract infections, many of which are nosocomial [4–8]. There are a number of mechanisms for the development of pneumonia in the severely burnt. Pulmonary complications are common with inhalational injury, but burnt patients have more pulmonary complications even without direct lung injury. Atelectasis and hypostatic pneumonia are common due to altered ventilation and reduced lung expansion that may occur in patients with chest or abdominal burns. These patients also have a high risk of aspirating, and respiratory physiotherapy with regular airway suctioning may be critical to maintaining pulmonary function [5,9].

Patients who require prolonged ventilation are also at risk of developing ventilator-associated pneumonia (VAP), which is a nosocomial lower respiratory tract infection in ventilated patients. Prior to 2007, VAP could only be diagnosed after 48 h of mechanical ventilation, but no minimum time of ventilation is now required to make the diagnosis [5,10]. Despite this change in definition, there may still be some utility in considering patients in early or late groups, because causative organisms and their resistance patterns vary in relation to this. In the paediatric intensive care setting, VAP is responsible for significant morbidity and mortality, and ranks as the second commonest hospital acquired infection. In fact, a large European trial in a variety of paediatric settings showed that VAP accounted for over half of significant hospital-acquired infections in the PICU [11]. The prevalence of nosocomial pneumonia in the ICU ranges from 10 to 65% and mortality rates exceed 25%. Those who develop VAP are twice as likely to die compared to those without VAP, the organisms are more resistant to therapy and the patients spend longer in intensive care [7,8,11,12].

There is a paucity of literature on VAP in children, and particularly within the context of major paediatric burns. International guidelines for the prevention and management of VAP have largely been extrapolated from adult experience with VAP. Burns patients, and particularly paediatric patients with burns, are a special group, with peculiar demands and predispositions, and should be managed by burns surgeons, anaesthetists, specialist nursing staff, paediatric intensivists, physiotherapists and occupational therapists with special interest and experience in managing severely burnt children.

The intention of this study was twofold:

1. To describe the incidence and epidemiology of ventilator associated pneumonia (VAP) in this patient group in the setting of Red Cross War Memorial Children’s Hospital.
2. To undertake a comprehensive literature review to determine strategies for the cost-effective diagnosis, prevention and management of ventilator associated pneumonia in the context of paediatric burns in resource-restricted settings.

## 2. Materials and methods

The Red Cross War Memorial Children’s Hospital is a 288-bed state teaching hospital with tertiary and regional functions. It is predominantly a referral hospital but also houses 24-hour trauma and emergency units, both with overnight inpatient beds. It is the only paediatric inpatient facility for the central health districts of Cape Town. Its tertiary services, including an intensive care unit (PICU), receive referrals from southern, central and western parts of Cape Town, the southern half of the western Cape, other tertiary children’s services in the province, other provinces, as well as other African states. It serves children less than 13 years of age, the vast majority of whom are dependent on state services for their healthcare. Approximately 156 000 children attend the outpatient and emergency services each year, of whom about 18 000 are admitted.

The Red Cross War Memorial Children’s Hospital has the largest dedicated paediatric burns centre in South Africa with 18 beds, admitting more than 1000 patients annually. The adjacent Paediatric ICU is a 20-bed facility. It is a combined medical and surgical ICU with specialist consultant intensivists and registrars with paediatrics, anaesthetics, emergency medicine and surgical backgrounds. Burns patients are admitted to the ICU only if they require ventilation, at the discretion of the admitting surgeon in consultation with the resident ICU staff and consultants.

Patients admitted with burns who required ventilation in the Paediatric ICU were included in the study. The medical records were collected from a five-year period (January 2005 to December 2009). Patients were excluded from study if they had incomplete notes, or were ventilated for less than 48 h.

Patient data was obtained by review of patient records (demographics, clinical course) and laboratory data (chemistry, haematology, microbiology) from the hospital database. The following criteria were recorded and analyzed: demographic details, aetiology of burn, size of burn, presence of inhalational injury, incidence of pneumonia, incidence of VAP (the diagnosis as per the medical records, irrespective of the method of diagnosis), microbiology of specimens’ collection, method of specimen collection, length of mechanical ventilation, length of ICU stay and mortality.

Standard protocols were used during the emergency and acute phases of treatment, including the Parkland formula for fluid resuscitation, escharotomy if needed, early enteral nutritional support, topical wound care, early burn excision and grafting, and pain control. The South African Burn Society also publishes recommendations to guide burns care professionals [3,4]. Patients are managed with modern closed wound dressings and coverage strategies, including silver based products (Acticoat [13] and Aquacel Ag), and skin substitutes (Biobrane [14] and Supratel) when indicated. The unit aims to establish a national deceased donor allograft skin bank to improve access to cadaver skin nationally.

ICU admission was determined by the attending ICU registrar and consultant, and management within the unit was based on care bundles and established, evidence-based protocols [9]. Criteria for admission include: major burns exceeding 30% TBSA (total body surface area), extensive facial and neck burns (especially in small children), suspected or confirmed smoke or hot liquid inhalation, significant carbon monoxide poisoning, physical evidence of upper airway burns, potential for airway obstruction, high voltage electrical burns, depressed level of consciousness and hypoxic brain injury.
The clinical diagnosis of Ventilation Association Pneumonia (VAP) was based on published guidelines utilized by the ICU staff prior to 2010, supplemented by additional criteria [15,16] and based on the consensus of the critical care team during the management process. Criteria used included: new and persistent radiographic evidence of focal infiltrates 48 h or more after introducing mechanical ventilation; changes in ventilator or oxygenation parameters; the development of hypo- or hyperthermia; changes in white cell counts; cough; changes in chest signs; changes in the nature of endotracheal secretions; microbiological results from tracheal aspirates and broncho-alveolar lavage. Prior to 2007, VAP could only be diagnosed after 48 h of mechanical ventilation. No minimum time of ventilation is now required to make the diagnosis [11]. For the purposes of this study, conducted in part prior to the changes, the old definition is applied.

Data were recorded on a proforma and transferred to Excel (Microsoft Excel 2008 for Mac Version 12.3.0). Data were collected in the form of categoric and continuous variables, and analyzed where appropriate using Epi-info (http://www.cdc.gov/epiinfo). The relationship between interventions and end-points were evaluated. Descriptive statistics are used throughout. Significance is regarded as a p value of < 0.05 using the student’s t-test.

Institutional and departmental approval was obtained to complete the study. The project number assigned by the Department of Surgery Research Committee was 2013/055, and by the Human Research Ethics Committee 358/2013.

3. Results

Over a five-year period (January 2005 to December 2009), 108 patients were admitted to the PICU with burns. Sixteen patients were excluded from further study on the basis of either inadequate or incomplete records (n = 5) or because the patient was ventilated for a period shorter than 48 h (n = 11). The mean patient age was 3.5 years (range 4 months to 13 years, median 1.67 years). 59% (n = 54) of the patients were male and 41% (n = 38) were female. The mean percentage total body surface area (TBSA) burn was 30% (median 26%, range 3–90%). 72% of the patients (n = 66) had deep dermal or full thickness burns requiring early escharectomy.

Scald and flame burns were the commonest mechanisms of injury. 63% (n = 58) of the patients sustained flame burns, 33% (n = 30) scalds and 4 sustained other kinds of burns (contact, electrical or chemical). Twenty patients had documented evidence of inhalational burns (22% of the total group, 32% of the flame burn group). Scald injuries occurred most commonly in the very young, with a mean age of 1.63 years (range 0.3–9 years), whereas the mean age of those who sustained flame burns was 5.12 years (range 0.25–13 years). Scalds comprise three-quarters of admissions to the burns unit; less than 1% of scald burn patients require ventilation. Many of these patients receive much of their treatment as outpatients. A higher proportion of flame burn wounds require excision and grafting, and up to 3% of these patients require mechanical ventilation during their hospital stay.

53% (n = 49) of the patients were admitted to the PICU within 12 h of the injury. Patients who sustained flame burns were far more likely to be admitted early in their clinical course, with 57% (n = 33) admitted in the first 12 h and 84% (n = 49) within the first 24 h. Only 7% (n = 4) of flame burnt children were admitted for the first time after 48 h. As many as 36% (n = 11) of scalds are only admitted to the PICU for the first time between 48 h and one week after the injury.

57% (n = 52) of the patients were diagnosed and treated for at least one episode of pneumonia during their clinical course (59 total episodes of pneumonia). Of these, 41 episodes (in 37 patients) met the criteria for ventilator-associated pneumonia (VAP). 18 of the episodes (in 15 patients) did not meet the unit’s criteria for VAP, usually because they had manifested clinical features of pneumonia prior to 48 h. of ventilation (as per the previous definition of VAP) (Fig. 1). The rate of VAP was 30 infections per 1000 ventilator days. The average TBSA of patients who developed VAP was 31%, not significantly different from the rest of the group. 43% of the patients (n = 40), despite being ventilated, did not develop pneumonia.

The mean number of re-intubations was 1.47 per patient (range 0–6); re-intubations followed failed weaning trials were usually a consequence of airway inflammation rather than hypoventilation. The mean ICU stay was 10.6 days (range 2–61 days), 14 days for those who died (range 2–46 days), and 15.4 days for those with VAP. The mean ventilation time was 8.4 days (range 2–31 days, median 9 days). The mean number of ventilation days was at least three days longer in those with VAP compared to those without. The mean number of theatre visits during the ICU stay was 5.4 (range 2–19). Length of ICU stay correlated with a significantly increased incidence of VAP (p < 0.05). Only seven tracheostomies were performed; all of these patients had prolonged ICU stays and three developed VAP. Selected results are compared between those with and those without VAP in Fig. 2.

The investigative modality deemed most important when deciding to initiate antibiotics for pneumonia (as documented in the patient records) was chest X-ray findings (34%), organism culture (27%) and clinical examination (39%). The Clinical Pulmonary Infection Score (CPIS) (Fig. 3) was inconsistently recorded during this period.

75 organisms were cultured and deemed responsible for pneumonia in 59 episodes in 52 patients during their stay in ICU. Broncho-alveolar lavage (BAL) identified the responsible organism in 16 of the 59 pneumonias, tracheal aspirates (34) and sputum the remainder. Antibiotics were more likely to be adjusted according to the BAL result than the alternative

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**Fig. 1 – Ventilator associated pneumonia (VAP) and Pneumonia (not diagnosed as VAP) in patients ventilated over five years.**
Streptococcus pneumoniae was the aetiological organism in 18 cases. Other important organisms in the whole group included Pseudomonas aeruginosa, Acinetobacter baumannii and Staphylococcus aureus. VAP was caused by Acinetobacter baumannii in 13 cases. Pseudomonas aeruginosa (n = 9), Staphylococcus aureus (n = 9) and Streptococcus pneumoniae (n = 7) were other prominent aetiological organisms. In two patients with VAP, viruses were responsible.

The other pneumonias (i.e. the group not classified as VAP) were caused by Streptococcus pneumoniae (n = 13), Haemophilus influenzae (n = 7), Pseudomonas aeruginosa (n = 5), Klebsiella pneumoniae (n = 4) and Moraxella catarrhalis (n = 4). Acinetobacter baumannii was only cultured in one of these cases. Streptococcus pneumoniae infection was commonly associated with culture of other organisms such as Moraxella catarrhalis and Haemophilus influenzae. There was one case of Tuberculosis and two cases of viral pneumonias in this category. Fig. 4 is a summary of prominent organisms in each category.

There is a significant degree of resistance in the PICU setting; both Acinetobacter baumannii and Klebsiella pneumonia demonstrate extended spectrum beta lactamase production in excess of 20%, and Pseudomonas aeruginosa cultured demonstrates a similar degree of carbapenem resistance.

Most patients (n = 54, 91.5%) were receiving empiric intravenous antibiotics prior to organism identification. Bloodstream infections (positive blood cultures) were documented in 31 patients, with 43 organisms. In 9 cases (15%) of pneumonia the organism (with a similar sensitivity profile) was also cultured from the burn wound; most frequently this organism was Pseudomonas aeruginosa. In 16 episodes (27%) the causative organism was also cultured from the bloodstream.

17.4% (n = 16) of the patients died. 63% (n = 10) of those who died had sustained flame burns, whereas 25% (n = 4) had sustained scalds and one each had electrical and chemical burns. The average TBSA of those who died was 46.8% (range 8–90%, median 35%), significantly different from the mean TBSA of the whole group, which was 30% (range 3–90%, median 26%) (p < 0.05).

Half (n = 8) of the deaths can be attributed to pneumonia. Six of these patients had VAP (causative organisms were Klebsiella pneumoniae in one case and Acinetobacter baumannii in three cases). Seven of the patients died of overwhelming Pseudomonas aeruginosa sepsis. Multiorgan dysfunction and head trauma comprised the remaining causes of death. One patient manifested features of fluid creep, and required laparotomy for abdominal compartment syndrome and fasciotomies for unburnt limbs [4].

### Discussion

Many of the severely burnt children who are admitted to hospital and die, will die in the intensive care setting of complications of either burn wound infections or pneumonia. There is a notable absence of literature related to VAP in the paediatric burns setting, especially from the developing world, despite the recognition that burns is a significant independent risk factor for VAP [6,7]. Nevertheless, much has been written in the critical care literature about the prominent role that VAP...
plays in respect of mortality and morbidity in the ICU. Burns victims have the highest relative risk of any category of ventilated patients: several studies have demonstrated that the incidence of VAP in burns patients is more than 22 per 1000 ventilator days, more than double that seen in either surgical or medical cohorts [5,8]. The rate in this study was 30 episodes per 1000 ventilator days.

VAP usually results from pathogens colonizing the lower respiratory tract and parenchyma by sustained micro aspiration, and less commonly from haematogenous spread. Burnt patients have a number of specific risk factors for developing VAP including detrimental systemic effects such as depression of the immune system, overwhelming inflammation, and contamination of the burn wound itself, inhalation injury, as well as the prolonged mechanical ventilation and ICU stay. Fig. 5 tabulates factors predisposing to pneumonia in burnt patients.

The diagnosis of VAP remains one of the greatest challenges to the intensivist, but especially in the burnt patient, who frequently exhibits pulmonary dysfunction due to inhalational injury, overwhelming systemic inflammation, pulmonary oedema and ARDS. Fever, sputum, leukocytosis or leukopaenia, deranged oxygenation, and abnormal chest radiographs may also all be present in a burns patient without pneumonia [5–7]. Although there are a number of proposed definitions, for the purposes of this retrospective study, VAP was defined as a clinical diagnosis (consensus of the critical care team) of a nosocomial lower respiratory tract infection which occurs in mechanically ventilated patients 48 h or more after initiating ventilator support, combined with radiological features and microbiological evidence [5,9].

Scoring systems like the Clinical Pulmonary Infection Score (CPIS) have been compiled to improve the accuracy by combining clinical, microbiological and radiological criteria. Scores of more than six are regarded as diagnostic (Fig. 3) [16–18]. The CPIS has recently (since the completion of this study) been validated at this hospital in the general pediatric ICU population and every ventilated patient is now allocated a score on a daily basis. This has resulted in a reduction in the incidence of VAP by improving awareness of preventative strategies, and implementing timely directed therapy according to the local bacterial milieu [12].

VAP is a prominent cause of morbidity and mortality in our burnt patients, but can also be preceded by lung pathology. Fourteen of the cohort had evidence of pneumonia prior to 48 h of ventilation. These patients are also at high risk, particularly if they had large body surface burn wounds. The traditional definition requiring 48 h of ventilation (to make the diagnosis of VAP) has been revised. 48 h is considered an arbitrary time period, but its use can be justified in that it better reflects contributing factors such as inhalational injury, pre-hospital and emergency intubation, pre-existing reactive airway disease, the different spectrum of bacteria responsible (community acquired versus nosocomial) and the efficacy of preventative and therapeutic measures. Of the organisms responsible for VAP, Acinetobacter baumanii has proved to one of most prevalent and virulent.

Broncho-alveolar lavage, protected specimen brush or non-bronchoscopic lavage are the best means of obtaining reliable quantitative cultures. By combining one of these techniques with clinical features of pulmonary infection, the sensitivity and specificity may be optimized [6,9,11]. Despite resource limitations, these techniques have been more frequently utilized in recent times [12].

Means of preventing VAP in burns patients have largely been adapted from studies focusing on other patient groups. Many of these have been incorporated into so-called ‘care bundles’ for ventilated patients. Fig. 6 lists some strategies applied in our unit. Daily interruptions of sedation and daily spontaneous breathing trials may facilitate early extubation [5]. Its role in children is less well established, but the principal of reducing ventilation duration to shortest possible is obviously paramount. The initial reason for intubation is usually related to the magnitude of the burn, significant and progressive facial and or cervical swelling, inhalational injury below the larynx and deterioration of airway patency. The diagnosis of inhalational injury is based on history and clinical findings and corroborated with direct vision or fibre-optic laryngoscopy.

There is insufficient data to support either oral or nasal intubation methods in paediatric practice, although orotracheal tubes are more prone to displace, which may necessitate re-intubation [9]. Adaptations to the endotracheal tube have been examined in an attempt to reduce the
incidence of VAP. The NASCENT trial showed a 40% risk reduction when silver impregnated endotracheal tubes were used [19]. Techniques to continuously aspirate subglottic secretions have been shown to be effective in adults, but are not verified in children, and therefore are not yet applied in this unit [9,20].

Noninvasive ventilation strategies are being utilized with increasing efficacy. This is however unlikely to be appropriate for most severely burnt children requiring ventilator support because compliance is seldom adequate. Nevertheless, the principle of limiting invasive endotracheal intubation and ventilation must be considered whenever possible. Recently, NIPPV helmets have been designed for this purpose and may be applied in older children [21].

Stress ulcer prophylaxis and early enteral nutrition are now well-established in both burns care and in the ICU scenario. Gastritis is rare in the well-resuscitated child burn victim and stress ulcer prophylaxis should not be routinely used as data to support its use is lacking [9]. Postpyloric feeding rather than gastric feeding may reduce the incidence of VAP [9]. Whenever possible, it is the practice of this unit to place a naso-jejunal tube for early enteral feeding during the process of resuscitation. There have been a number of benefits to this strategy, not least in the perioperative period, when physiological feeding methods may be continued despite pending theatre visits and procedures. Placing the patient in the semi-recumbent position is effective and easily applied in the adult, but may prove difficult in the paediatric population where there may be marked size differences between patients. Wedge shaped mattresses of various sizes and objects placed under the legs of the bed have been inconsistently applied [9].

Meta-analyses have shown a significant reduction in the incidence of pneumonia with the use of selective decontamination of the gastro-intestinal tract in adults [22,23], but have not been applied in children in this setting due to concerns about increased resistance [12]. Chlorhexidine mouthwash has been a routine, easily applied and cost-effective strategy for reducing VAP [24,25]. Contact precautions and hand hygiene are now well-established tenets of critical care, and adherence to these and other elements in the ventilator care bundles need to be regularly reviewed [26]. With the open structure of our paediatric ICU, the regular use of alcohol based hand wash, gloves and aprons are important simple measures to improve infection control. Maintaining low nurse-to-patient ratios in the ICU is equally important, but may be more difficult to apply in resource-restricted settings. The ‘care bundles’ introduced in this PICU are predominantly simple inexpensive methods for resource-limited settings, and include: head of the bed elevation, fastidious oral hygiene, limited sedation, early weaning and extubation, correct positioning of tubing and the avoidance of saline use during suctioning.

Patients with deep burns frequently require blood transfusions during their course of treatment. A restrictive policy should be adhered to, as each unit of blood received has been associated with a 13% increased risk of infection, presumably by exacerbating the state of immunosuppression [27,28]. Prior to major surgery, we ensure that our patient’s haemoglobin exceeds 10g%, and we make regular use of packed red blood cells for transfusion, and adrenaline-containing solutions for infiltration (‘clysis’) and topical application during surgery.

Intense insulin therapy and tight glucose control, despite initial optimism, needs to be re-evaluated in a major trial, and particularly in major paediatric burns. The consequences of hypoglycaemia are potentially catastrophic, and more significant than the potentiation of infection during periods of high normoglycaemia, or even hyperglycaemia [29,30].

Probiotics have been identified as a potentially useful adjunct to the VAP bundle. Proposed mechanisms have included: to increase mucous production and the barrier function of the gut; competition with pathogens for epithelial adherence; an up-regulating effect on the secretion of host cell antimicrobial peptides; direct pathogen killing and immunomodulation and induction of lymphoid cells. There has been conclusive evidence due to variability across studies with respect to probiotic strain, dosing, duration, route of administration, and diagnostic criteria for VAP. As such, we require more rigorous multi-centre studies to justify use of this strategy at this time [31].

Several studies have demonstrated that a delay in initiating appropriate antibiotics may result in increased morbidity and mortality. Consequently, units should be aware of their local bacterial milieu and resistance patterns, to guide appropriate empiric antibiotic choices [6,9,11]. Early pneumonias in ventilated patients are more likely to be acquired, most notably Streptococcus pneumonia and Haemophilus influenzae, and are more likely to be susceptible to antibiotic therapy. This is in contrast to later onset VAP’s, more likely a consequence of Acinetobacter baumannii, Pseudomonas aeruginosa, Staphylococci, and gram-negative organisms (E. Coli and Klebsiella pneumonia) [6]. The current protocol in this hospital complex dictates that the on-call microbiologist be consulted prior to initiating empiric antibiotics. Erthropenam is now the empiric antibiotic choice for hospital acquired pneumonias, with the addition of vancomycin if staphylococcus is suspected. Piperacillin/tazobactam, carbapenams or quinolones may be dictated by the prevalence of highly resistant organisms.

Of great concern has been the identification of viruses contributing to the severity of VAP. Before April 2009, viral isolation and identification techniques were suboptimal and dependent on cell cultures or antigen detection. This could explain the low yield of viral respiratory pathogens in this study, but viral identification is now an integral investigation in children on mechanical ventilation [32].

We are still dependent on alternatives to invasive quantitative microbiological techniques, like sputum cultures and tracheal aspirates. The results of these tests are relatively unreliable and treatment should be initiated and de-escalated with this is mind. If possible, empiric therapy should be limited to 48h: this period of use should not increase resistance [5,6,33,34]. Antibiotics may safely be stopped once clinical features of infection have resolved. There is probably no difference in outcomes if an eight- or fifteen-day course of treatment is implemented, unless the organism responsible is P. aeruginosa or Acinetobacter, for which a longer course is necessary to reduce recurrence [35]. Fig. 7 outlines a broad diagnostic and therapeutic algorithm for VAP.
5. Conclusions

Major burns victims are particularly susceptible to pneumonia, especially ventilator-associated pneumonia. VAP is a prominent cause of morbidity and mortality, despite improvements in intensive care and burns surgery in recent times. Inhalational injury, length of ventilation and the type and size of the burn correlate with the incidence of VAP. Other risk factors (number of re-intubations, theatre visits) are also important.

Effective preventative strategies should be adhered to, and protocols should be implemented to aid in the diagnosis and treatment of VAP. Clinical criteria, radiology, and bronchoalveolar lavage should be used to determine the causative organism, and there should be a low threshold for the early initiation of broad spectrum empiric therapy, based on the prevailing resistance patterns in the unit. Major burns should be managed in centres where there is ready access to multi-disciplinary resources and expertise.

Conflict of interest

There are no conflicts of interest to declare.

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