

SERIAL HAEMODYNAMIC CHANGES IN CHILDREN WITH ACUTE EMPYEMA

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ABSTRACT

Empyema thoracis continues to remain a serious complication of Pneumonia in children. A number of studies are available on demographics, etiology and treatment of empyema but no useful information is available on hemodynamic changes occurring in response to acute empyema. Therefore we aimed to evaluate the serial haemodynamic changes in children with acute empyema and their correlation with severity and outcome of the disease.

Serial haemodynamic changes were studied prospectively in 25 children with acute empyema before and after the placement of chest tube and subsequently on day 1, 2, 3 and 10 of hospitalization. Twenty-five age and sex matched children served as their controls.

Their age ranged from 8 months to 12 years (mean 4.2 years). Severity of empyema was graded as mild, moderate and severe in 11, 6 and 8 children respectively. Staphylococcus aureus was the commonest organism isolated in 11 children. At admission all the children were febrile (mean temp 39.4°C) had tachycardia (mean HR 136/mt) and tachypnea (mean RR 62/mt). While CVP was high (10.2 ± 4 cm H₂O), the systolic (102 ± 4 mmHg) and mean arterial pressure (77 ± 3 mmHg) was at lower side as compared to their controls. The mean changes observed after the chest tube placement were HR - 6/mt; RR - 4.44/mt; SBP + 5 mmHg; DBP + 2.04 mmHg; MAP + 3 mmHg and CVP - 3.1 cm H₂O (p < .001). Children with severe disease had significantly higher CVP (15 ± 3.3 cm H₂O), low SBP (99 ± 3 mmHg) and low serum Sodium (128 ± 5 mEq/L) and Osmolality (278 ± 9 mOsm/L) compared to those with mild or moderate disease. (p < .05 for each factor). Seven children had features suggestive of syndrome of inappropriate ADH secretion. All these children belonged to severe category.

It was concluded that hemodynamic compromise is a common occurrence in children with empyema. High CVP, low SBP, low serum Na⁺ and Osmolality correlate best with the severity of the disease.

Key Words: *Empyema, Hemodynamics, Children.*

INTRODUCTION

In children, empyema thoracis accounts for 8.6% of hospital admissions for lower respiratory infections and about 2% of total hospital admissions in developing countries.^{1,2,3} In an epidemiological investigation, Byrington et al indicated much higher rate of empyema (30%) as post pneumonia

complications.⁴ The death rate of empyema varies from 1.3%-36% in hospitalized children.^{3,5} Mostly, deaths are reported within 48-72 hours of hospitalization and have been attributed to the unrelieved tension inside the thoracic cavity.^{2,6} In a recent study all the deaths of childhood empyema (6.3%) were attributed to heart failure with congestive heart failure reported as a most frequent complication in empyema (33.3%).⁷

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There is paucity of information about the effect of increasing tension inside the thoracic cavity on hemodynamic status in children with diseased lungs. Hence this study was planned to study the serial hemodynamic changes in children with empyema. Their understanding can help us in providing better supportive care for seriously ill children with acute empyema.

MATERIAL AND METHODS

This prospective designed study comprises of 25 children aged, 8 months to 12 years admitted with the diagnosis of acute empyema (< 2 weeks duration). Fifteen (60%) were boys and 10 (40%) girls. Twenty-five age and sex matched children with minor problem served as their controls. Children with tuberculosis, systemic diseases and malnutrition (wt for age < 60% of expected) respiratory disease (>2 weeks duration), were excluded from the study. The diagnosis of empyema was confirmed by aspiration of pus from pleural cavity and all the children were managed in ICU according to the standard protocol comprising of antibiotics (cloxacillin/ co-amoxycylav + Aminoglycosides), closed tube drainage, I/V fluids and O₂ if required, subsequent changes in antibiotics were made according to culture sensitivity/ clinical response.

The Parameters used to assess the hemodynamic changes were HR, RR, BP, CVP, Oxygen saturation and serum and urinary osmolality. The recordings of clinical variables were done as per the standard guidelines⁸. The changes were recorded at the time of admission, before and after 30 minutes of chest tube placement and subsequently on day 1, 2, 3 and 10 of hospitalization. The CVP was recorded in children with empyema only for first 3 days. The values for HR, RR, BP and CVP represented average of four observations made on that particular day. Empyema was outlined in to 3 grades according to clinical, CXR and USG findings

Mild : unilateral, chest x ray fluid level < 4th rib. In USG uniloculated collection, Other lung normal, no mediastinal shift.

Moderate : unilateral, CXR- fluid level < 2nd rib .In USG uniloculated collection, Other lung normal / pneumonitis, mediastinal shift.

Severe : bilateral/ unilateral CXR with fluid level >2nd rib, In USG multiloculated, Other lung pneumonitis, mediastinal shift.

The data were expressed as mean \pm SD, paired t test was used to analyze the significance of hemodynamic changes before and after chest tube placement, and for groups comparison two tailed t test was used. Karl-Pearson coefficient of correlations was used to determine the associations and multivariable regression analysis was done for individual significance. P value <0.05 was taken as significant.

RESULTS

All the children with empyema had fever and cough of 2-12 days duration. Difficulty in breathing and feeding problems were observed in 92% and 60% of the children with an average duration of 4 days and 2.6 days respectively. Staphylococcus aureus was isolated from the pleural fluid in 13 (52%) cases and streptococcus pneumoniae and Klebsiella one in each case. Eight children developed complications as; bronchopleural fistula in 3, chronic empyema in 3 and pericardial effusion in 2 cases. One child died within 12 hours of hospitalization also had anemia (HB 7.8gm%) meningitis and dilutional Hyponatremia (serum Na⁺ 122 mEq/L, plasma osmolality 264 mOsm/L).

Haemodynamic Changes

Table I show serial changes before and after putting ICT and subsequently on day1, 2, 3 and day 10 were lower than their controls (SBP 107.8 \pm 3 mmHg, DBP 68.6 \pm 2.5 mmHg and MAP 81.76 \pm 1.4 mmHg respectively, p< 0.001) and their own values recorded subsequently.

The mean changes observed after placement of intercostal tube were: HR - 6 beats/mt; RR- 4.44 breaths/mt; SBP +5 mm Hg; MAP + 3 mm Hg and CVP -3.1 cm H₂O (p < 0.001). Though the maximum fall in CVP was observed after chest tube drainage, it continued to fall for subsequent 3 days. Seven cases had hyponatremia (serum Na⁺ 127 \pm 4.5 mEq/L), hypoosmolality (277. \pm 8.7mOsm/L) and relatively higher urinary osmolality (466 \pm 70mOsm/L). Hemodynamic changes observed by day 10 of hospitalization were comparable with controls.

Hemodynamic Changes and Severity/Outcome of Disease

While comparing the hemodynamic changes in 3 groups of patients before putting ICT, the values for heart rate and CVP

Table I : Serial haemodynamic changes in Children with acute empyema

Variables	Before ICT	After ICT	Day 1	Day 2	Day 3	Day 10
HR (/mt)	136 \pm 14	130 \pm 13*	120 \pm 13 [#]	116 \pm 11*	111 \pm 10*	99 \pm 7 [#]
SBP (mmHg)	102 \pm 4	107 \pm 3 [#]	108 \pm 3	107 \pm 3	108 \pm 2	108 \pm 3
MAP (mmHg)	77 \pm 3	80 \pm 2 [#]	81 \pm 2 [#]	81 \pm 2	81 \pm 2	82 \pm 3
CVP (cm H ₂ O)	10.2 \pm 4.1	7.1 \pm 2.1 [#]	6.2 \pm 1.5*	5.2 \pm 1.3 [#]	4.5 \pm 0.9 [#]	---
SPO ₂	91 \pm 5	93.5 \pm 4	96 \pm 3	97 \pm 3	96 \pm 2	97 \pm 3

*All values mean \pm SD * p value <0.001, # p value <0.0001 with respect to the changes before ICT*

Table II : Haemodynamic variable before putting chest tube according to the severity of the disease

Severity	HR/mt	RR/mt	SBP mmHg	CVP cmH ₂ O	SPO ₂ %	Na ⁺ mEq/L	Serum Osmolality mOsM/L
Mild (n = 11)	130±15	60±8	103±5	7.5±1	98±1	137±2	292±4
Moderate (n = 6)	139±14	65±4	104±2	93±	97±1	136±5	288±6
Severe (n = 8)	142±13	64±6	99±3*	15±3.3 [#]	89±2	128±5*	278±9*

* $p < 0.05$ as compared to mild, * $p < 0.05$ as compared to moderate

were higher in cases with severe disease, where as the values for blood pressure, serum sodium and serum osmolality were lowest (Table 2). Following ICT placement an overall improvement was observed in all the children, although, the changes were more marked in those with severe disease. The variables which correlated best with the severity of empyema were; CVP, SBP, Serum sodium, and serum osmolality ($r = 0.76, -0.72, -0.62$ and -0.67 respectively, $p < 0.01$). On multivariable regression analysis CVP was found to be the best determinant of severity of empyema.

With respect to the outcome, children who had complications, continue to have higher RR and temp. (RR: 61.7±2.5, temp: 39.7±0.3) as compared to those without complications (RR: 56.7±6.3, temp: 38.0±0.6, $p < 0.05$). No other variables correlated significantly with the outcome of disease.

DISCUSSION

The main hemodynamic abnormalities observed in Children with acute empyema were low systolic BP, raised CVP, hypoxia and evidence of dilutional hyponatremia beside tachycardia and tachypnea. Grossfield and Coworkers studied the effects of increased intrathoracic pressure in an experimental model of cats. The lungs were subjected to pressures up to 70 cm H₂O. Early haemodynamic changes included tachycardia, tachypnea, hypoxia and systolic hypertension followed by progressive hypotension and increased vena caval pressure.⁹ Subsequently similar observations were reported in patients with pneumothorax and pneumomediastinum.^{10,11} Krishna et al found a significant fall in HR, RR, CVP and improvement in SBP, DBP, MAP after placement of mediastinal tube in children with pneumomediastinum.¹¹ Though we also observed a similar trend in hemodynamics following I.C.T. drainage of empyema, complete normalization however was not achieved. Underlying diseased lungs, infection, altered fluid and electrolyte status possibly contributed for the same. A recent study in a developing country demonstrated congestive heart failure as a most common complication in childhood empyema thoracis (33.3%). All the deaths (6.3%) were attributed to heart failure and establish the importance of haemodynamic changes in empyema.⁷

Increased intrathoracic pressure has been found to be associated with raised pulmonary vascular resistance and decreased venous return,^{10,11} which may lead to fall in stroke volume and cardiac output, with a perception of hypovolemia and hypotension. Sreeram et al, demonstrated tricuspid regurgitation, elevation of right ventricular systolic pressure and pulmonary artery systolic pressure resulting in a significant increase in pulmonary vascular resistance in patients with acute respiratory infection.¹² As a compensatory mechanism, body tries to maintain the blood pressure by increasing the heart rate and blood volume (by retaining the body fluids). In children with severe pneumonia and other respiratory diseases a phenomenon of inappropriate secretion of anti diuretic hormone (SIADH) has been reported.¹³ Chan. W. indicated 4.2% cases of SIADH in their study of empyema in children.¹⁴ Hyponatremia, hypo osmolality and relatively high urinary osmolality observed in 7 cases in our study also suggest a similar phenomenon. Higher central venous pressure even after reduction of intrathoracic pressure in children with severe disease with a gradual fall observed over next 3 days favors the assumption of fluid retention in these children.

Most of the previous studies on empyema stressed upon the need of antibiotics and surgical procedures with very little information on supportive management in acute stage Fluid and electrolyte status and its relation with hemodynamic changes has always been overlooked. Our study attempts to demonstrate that haemodynamic approach to the treatment of empyema in addition to the conventional treatment have significant benefits in the early stage of empyema.

To conclude the children with acute empyema do have hemodynamic compromise of variable degree, depending upon the severity and associated problems. High CVP, low systolic BP with low serum sodium and osmolality correlate best with the severity of empyema. To minimize the mortality and morbidity associated with thoracic empyema, physicians should be aware of these possible changes in the hemodynamics of Empyema in children. These children require an individualized approach not only for intercostal tube drainage and antibiotics but also for supportive therapy and continuous monitoring of hemodynamic variables.

ABBREVIATIONS

HR, Heart Rate; RR, Respiratory Rate; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; CVP, Central Venous Pressure; MAP, Mean Arterial Pressure; ICT, Inter Costal Tube.

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