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Research Article

Role of Malnourishment, Anaemia and Hypoproteinemia in Children as Risk factors in Intracardiac Repair for Tetralogy of Fallot

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Abstract

Introduction: Malnourishment, anaemia and hypoproteinaemia (MAH) in underprivileged children as risk factors for Intra cardiac Repair for Tetralogy of Fallot have been studied globally. Determination of their role in the outcome in India is the goal of this retrospective analysis. Biomarkers for outcome are mortality and morbidity.

Materials and Methods: 750 Patients under 12yrs who underwent Intracardiac Repair for TOF in 3 centres between 1988 to 2019 were retrospectively analysed for Pre, intra, postoperative morphological and functional risk factors contributing to mortality and morbidity with special emphasis on malnourishment, anaemia and hypoproteinaemia. Data were analysed in 3 Chronological phases- 1988 - 2002, 2002 - 2013 and 2013 - 2019. Collaboration with Children's Hospital Boston divided first phase into Pre and Post IQIC. (International Quality Improvement Collaborative for Congenital Heart Disease). In the 2nd Stage of 1st Phase mortality reduced from 12% to 2% and Morbidity from 14% to 2%. Malnourishment was treated in the first phase with Ryle's tube and parenteral feeding before weaning from mechanical ventilation. Intra operative treatment of anaemia with hemic prime, reduced prime in the pump and decreased CPBP tubing lengths, hemofilter and postoperative treatment with blood products and whole fresh blood were effective. Hypoproteinaemia was treated with addition of albumin to the prime and plasma postoperatively.

Results: Analysis was for 3 phases in 3 centres. They were divided on the basis of state of Art equipment, trained, dedicated team and hospital with Paediatric multi specialties. First phase evolved from optimal infrastructure to State - of - Art. Second had optimal infrastructure and the 3rd had all three. 60% were between 1 - 5yrs and 25% below 1 year. 50% weighed between 10 - 15 Kgs. There was a preponderance of males. Malnourishment was in 87%, anaemia in 70%, hypoproteinaemia in 60%. Surgical era decided mortality due MAH - 12% in the first part of first phase became less than 2% in the phase. There was one morbidity in the 2nd phase and no mortality or morbidity in the 3rd phase. 23 other risk factors were analysed. Median Length of stay in ICU was 12 days (10 - 29 days). Median duration of mechanical ventilation was 96 hrs (48 - 120 hrs). While, RACH1 classification, residual RVOT obstruction, postoperative RV Function, myocardial protection, long CPBP time, ACC time, played important roles in the outcome, gross mortality for intracardiac repair is now 3%. (MAH) did not contribute to mortality in the second and Third phases. There was a strong correlation between morbidity, preoperative respiratory infection and postoperative infection, Morphological and functional characteristics influenced morbidity.

Conclusion: MAH in the early part of the First phase contributed to postoperative mortality 12%. It reduced to 2% in the second stage. Anaemia and hypoproteinemia (AH) when managed intra and post operatively, did not contribute to mortality in the second and third phases. There was one case in the 2nd phase that contributed to morbidity. In the 3rd phase, there were no mortality or morbidity.

Keywords: *TOF; Malnourishment; Anaemia; Hypo Proteinemia; Mortality; Morbidity; Risk Factors*

Introduction

Tetralogy of Fallot is a cyanotic disease. Prevalence of congenital heart defects within India is approximately 4 cases per 1,000 live births with TOF comprising 7 to 32% of these cases, making it among the most common congenital anomalies [2]. Since it is cyanotic and comprises a wide spectrum of morphological variations, it poses a surgical with management challenges of cyanosis. In this series of malnutrition, anaemia and hypoproteinaemia are additional challenges. State- of- Art infrastructure to meet the surgical challenge, a well-trained and dedicated team and a paediatric multispecialty hospital to meet management challenges are the basic essentials.as will be proved subsequently.

During the 1988 - 2019, 750 patients underwent intracardiac repair of tetralogy of Fallot. The patients ranged in age from 3 months to 12 years. Before operation. All were Cyanotic. Associated anomalies included atrial septal defect in 24 per cent, patent ductus arteriosus in 3 per cent, coronary anomalies in 2 per cent, and left superior vena cava in 4 per cent. We have not included patients with pulmonary atresia. Pulmonary valvotomy was performed in 350 patients. Patch graft reconstruction of the right ventricular outflow tract was performed in 43 per cent of the patients. Residual ventricular septal defect (VSD) was found in 8.3 reduced to 4 per cent of the patients and residual RVOTO in 11%reduced to 3%.

This retrospective study has been done in 3 centres in 3 phases. Irrespective of the centres there have been 3 phases based on the availability of State - of - Art infrastructure, a well-trained, dedicated team and a multi-specialty Hospital. Mortality and morbidity had been the biomarkers for outcome. Determination of the role of Malnourishment, Anaemia, and Hypoproteinemia (MAH) in the outcome was the goal. Mortality is defined as death in the hospital and within 30 days postoperatively. Morbidity is determined by increase in ICU stay for more than 7 days and mechanical ventilation for more than 48 hrs [1,2].

Materials and Methods

750 Patients under 12yrs with TOF who underwent intracardiac repair in 3 centres between 1988 to 2019 were retrospectively analysed for 23 Pre, intra, postoperative morphological and functional risk factors contributing to mortality and morbidity with special emphasis on malnourishment, anaemia and hypoproteinaemia. Data were analysed in 3 Chronological phases- 1988 - 2002, 2002 - 2013 and 2013 - 2019. 17 out of 23 risk factors contributed to mortality and morbidity. Malnourishment was treated in the first phase with Ryle's tube and parenteral feeding before weaning from mechanical ventilation. Intra operative treatment of anaemia with hemic prime, reduced prime in the pump and decreased CPBP tubing lengths, hemofilter and postoperative treatment with blood products and whole fresh blood were effective. Hypoproteinaemia was treated with addition of albumin to the prime and plasma postoperatively.

Results

Analysis was for 3 phases in 3 centres. First phase evolved from optimal infrastructure to State - of - Art. Second had optimal infrastructure and the 3rd had all three. 60% were between 1 - 5yrs and 25% below 1 year (Figure 1).

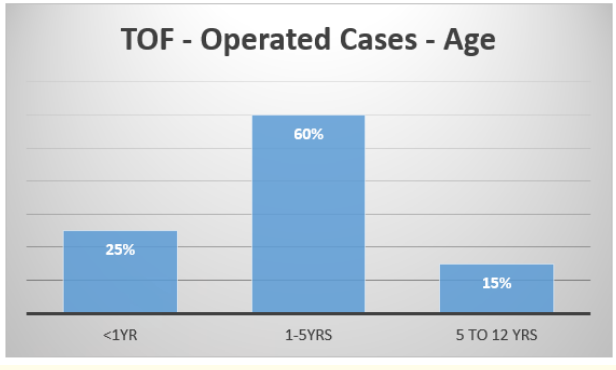

Figure 1: *60% of the children were from 1 - 5yrs of age.*

50% weighed between 10 - 15 Kgs (Figure 2).

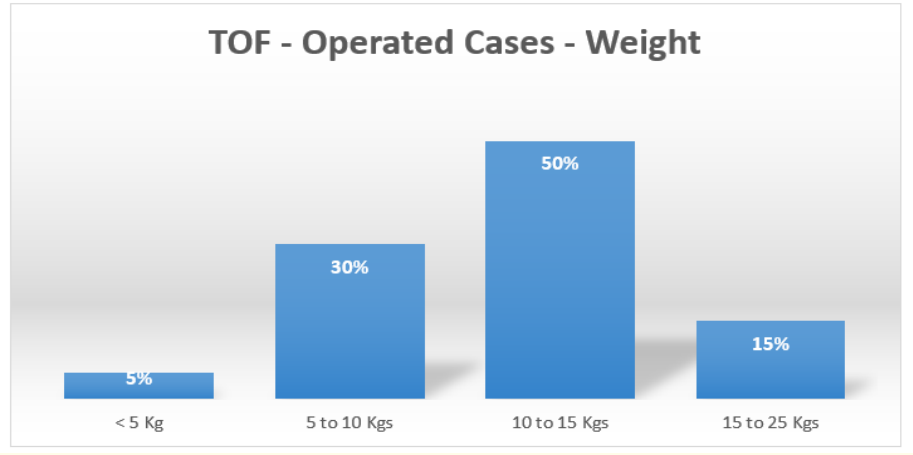

Figure 2: *50% were between 10 to 15 kgs, yet they belonged to older age malnourished group.*

There was a preponderance of males (Figure 3).

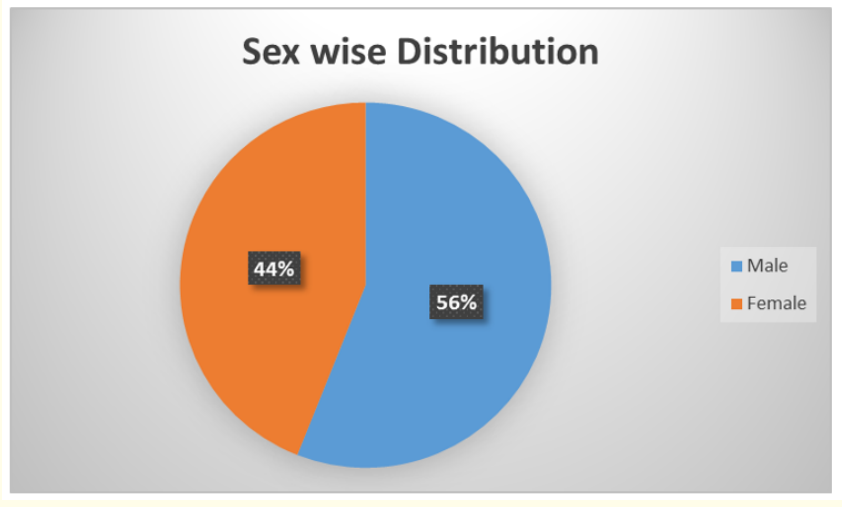

Figure 3: *There was a preponderance of males.*

Malnourishment was in 87%, anaemia in 70%, hypoproteinaemia in 60% (Figure 4).

Surgical era decided mortality due MAH - 12% in the first part of first phase became less than 2% in the second stage of same phase. There was no mortality but morbidity in one patient in the 2nd Phase. They was no mortality or morbidity due to malnourishment, anaemia and hypoproteinaemia in the 3rd phase (Figure 5 and 6).

Median Length of stay in ICU was 12 days (10 -29 days). Median duration of mechanical ventilation was 96 hrs (48 -120 hrs).

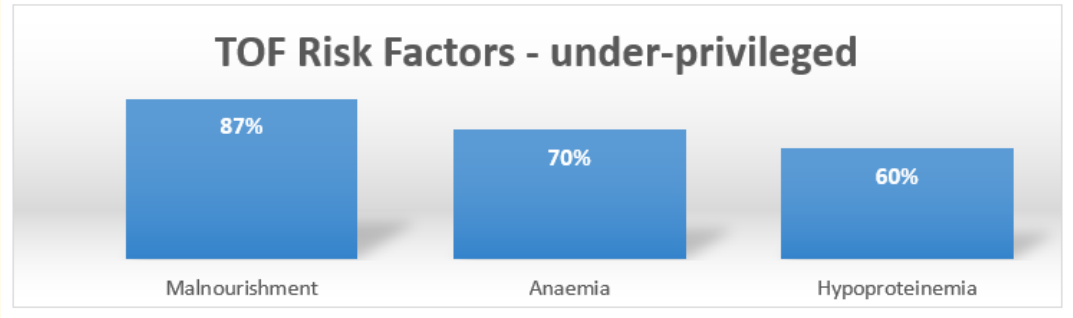

Figure 4: *Extra Risk factors for Intra-Cardiac Repair for TOF.*

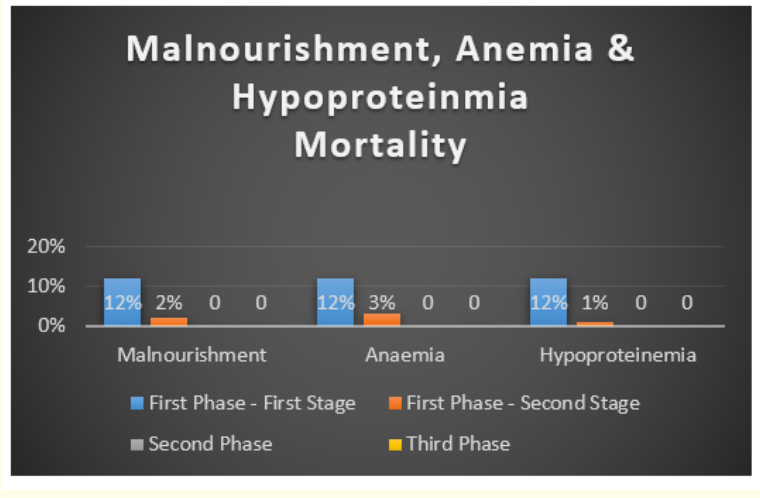

Figure 5: *Mortality due to malnourishment, anaemia and hypoproteinaemia.*

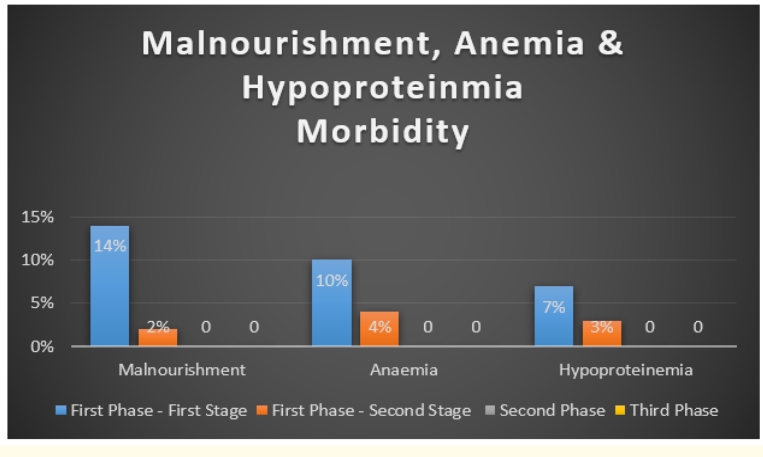

Figure 6: *Morbidity due to malnourishment, anaemia and hypoproteinemia.*

23 other risk factors were analysed. Out of them 17 played important roles in the outcome. While RACH1 classification, surgical technique, residual RVOT obstruction, long CPBP time, ACC time, RV function and myocardial protection played important roles in the outcome (Figure 7A and 7B) (MAH) did not contribute to mortality in the second and Third phases (Figure 7C).

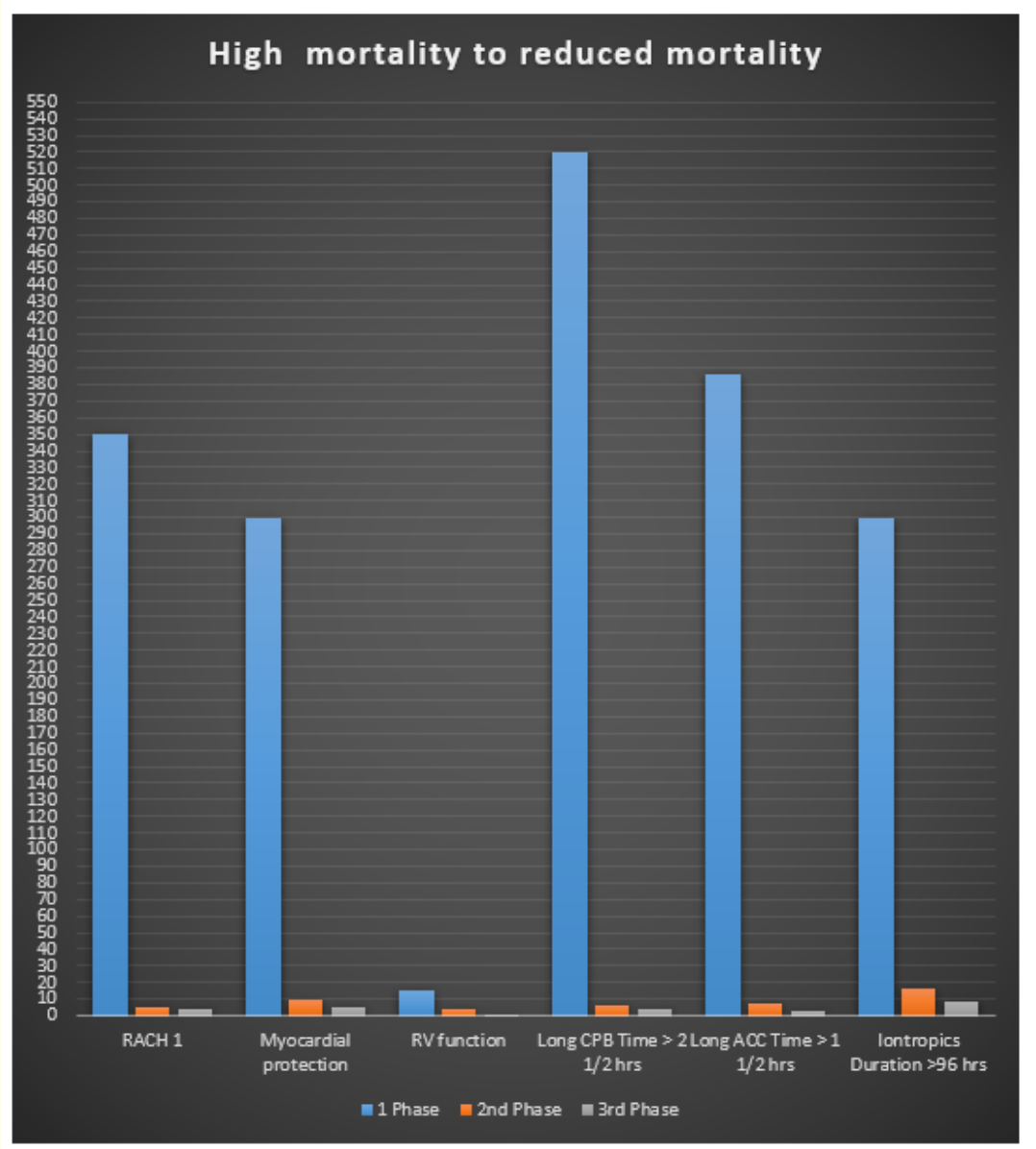

Figure 7A: *RACH1 category 2, morphology and surgical technique of repairing them, long CPB and ACC times, myocardial protection, RV outflow patch and RV function.*

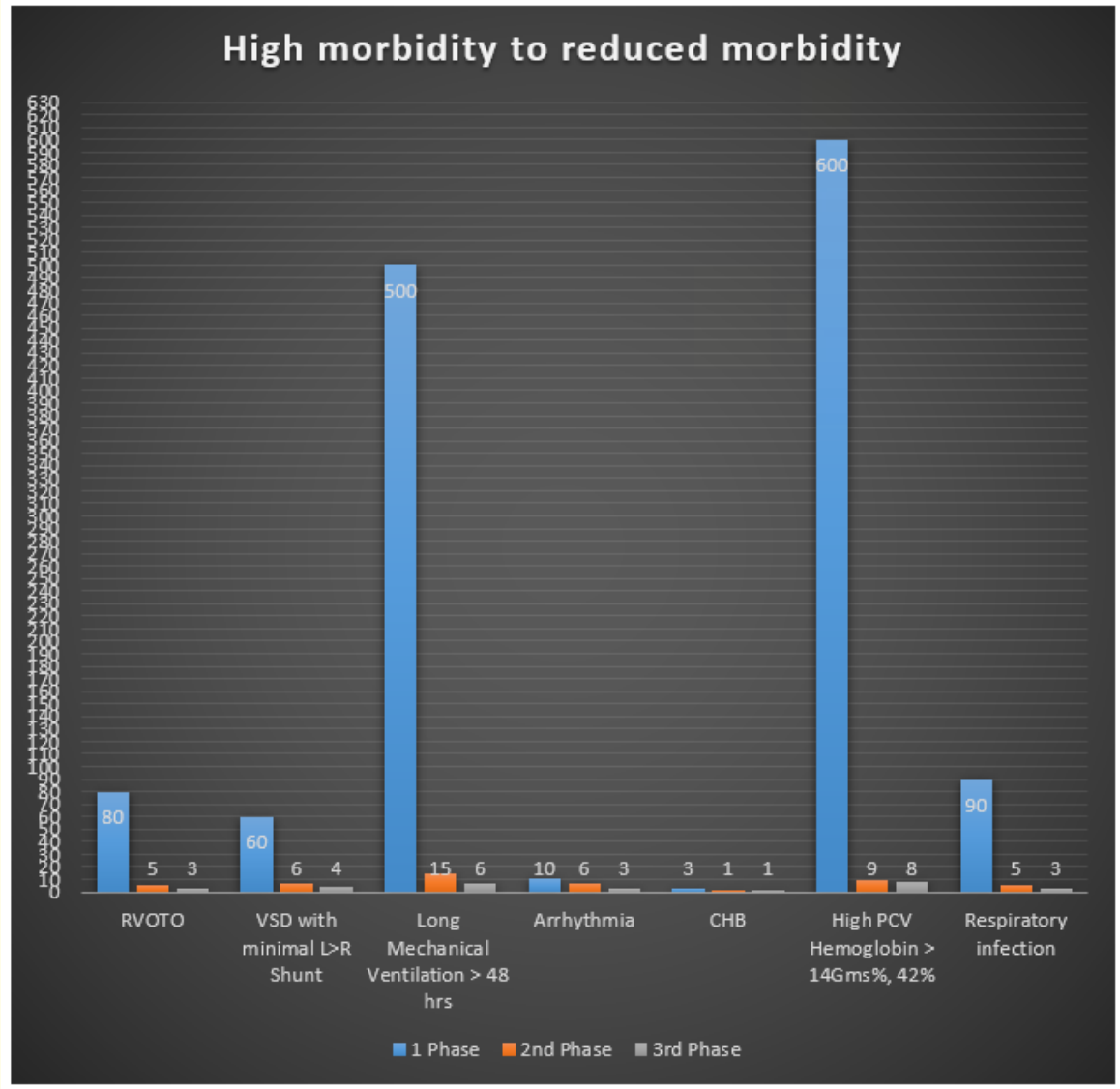

Figure 7B: *Residual RVOTO contributed maximally to morbidity.*

Discussion

First phase (1988 - 2002): Role of MAH on mortality and morbidity

In the beginning, this centre had optimal infrastructure which evolved into a State - of - Art towards the last 4 yrs. The surgical team was on a learning curve. Preoperative malnourishment, anaemia and hypoproteinaemia in underprivileged children as risk factors for cardiac surgery have been studied globally [4,5]. A non-linear relationship between low height-for-age and weight-for-age z-scores and mortality after surgery have been found. Significant association between malnutrition and 30-day mortality has also been noted. Malnutrition did

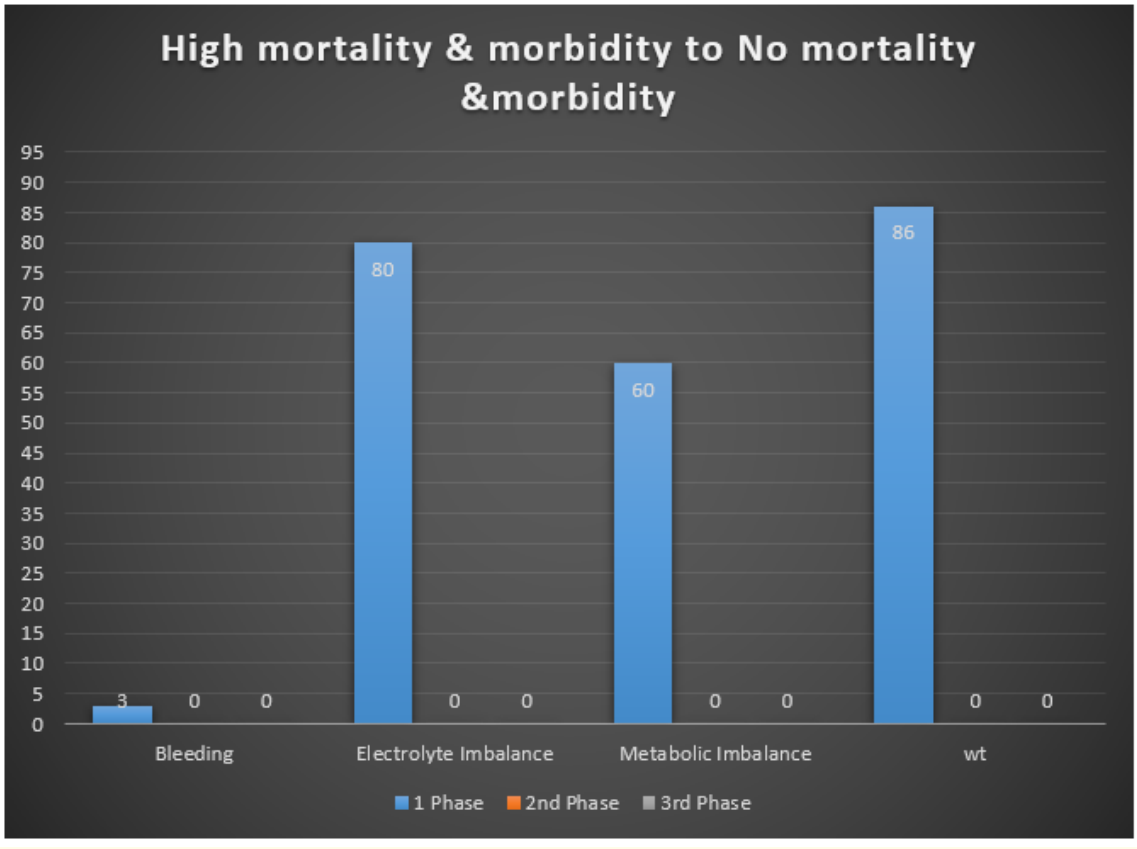

Figure 7C: *The above did not contribute to mortality or morbidity for they were treated soon after discovery.*

not contribute to mortality but to morbidity in one study [6]. In the present study, preoperative underweight malnourishment (87%) was a common feature. In the earlier years along with anaemia and hypoproteinaemia it played an important role in the outcome of a gross mortality of 12%. Intra operatively, Ryle's tube or parenteral nutrition were added. No effort was made to correct nutrition in the pre or intra or post - operative periods. Nutritional support at every stage has been emphasized in some studies [7-9].

Anaemia

Anaemia was in 70% of children. Iron deficiency anaemia has been the commonest as in other studies [10]. If level of PCV was less than three times the value of Hb, child was considered anaemic. Some studies have taken Hb below 12.5 gms% as the cut off level [11]. Highest in the present study has only been 11 gms% with a mean of 9 gms%. It was confirmed with Blood smear as per hematologist's opinion of Hypochromic, microcytic anaemia. There are studies that have shown adverse outcomes in combinations of cardiac disease with anaemia [10]. Ferritin levels and binding capacity were checked and Iron deficiency was treated with Iron orally [11,12]. Intra operatively maintenance of Hb gms% above 7.5 [13,14] has been emphasized. Haemic contracted prime with Hb of 9 gms% was used. Tube lengths were shortened and Paediatric membrane oxygenators were selected. Hemofilters with conscious effort to maintain negative intra and post-operative fluid balance were added. Maintaining Mean Artery Pressure between 40 - 50 mm of Hg, adding hemic prime, Blood cardioplegia, maintaining low volume with tube lengths tailored to individual patients and using Haemofilters have considerably decreased mortality and morbidity [15] Profound hypothermia with total circulatory arrest gradually gave way for moderate hypothermia and surface cooling. Maintenance was done with graded negative fluid balance monitored by optimal cardiac parameters These efforts reduced

gross mortality to 3.92% Meticulous haemostasis intraoperatively and infusing blood products early postoperatively have decreased mortality and morbidity due to coagulation abnormalities [16,17]. Preoperative evaluation by the haematologist and judicious reduction in viscosity by blood- letting, preoperative management of Chronic Disseminated intravascular coagulation (DIC) and preoperative use of steroids have reduced postoperative bleeding. Fresh whole blood with blood products both intra and postoperative periods helped in controlling postoperative bleeding.

Hypoproteinemia

Studies have a standard of Serum Albumin value below 4 gms% as the level for hypoproteinaemia [18,19]. Since in all these children values were below 4 gms%, < 3.5 gms% was selected as the cut off value. Albumin was added to the prime. Postoperatively there was a further fall which was treated with Albumin or Plasma [18]. Initially, hypoalbuminemia contributed to mortality and morbidity [19]. With addition of Albumin to the prime and Albumin infusion carefully postoperatively, it did not contribute to mortality or morbidity.

Second phase (2011- 2013): Role of MAH on mortality and morbidity

This phase was in the second centre with optimal infrastructure. The surgical team had acquired optimal maturity. There was no mortality due to MAH. There was one child with Ventricular Septal Defect who when reviewed after one month had entire superficial midsternotomy wound dehiscence due to hypoproteinaemia. With protein supplements wound healed well after 2 months

Third Phase (2013- 2019 date): Role of MAH on mortality and morbidity

In this phase of the third centre surgical team and the patients benefitted maximally through IQIC (International Quality Improvement Collaborative for Congenital Cardiac Diseases) with Children's Hospital, Boston. Meticulous care of risk factors from preoperative period to follow up further helped us in the analysis of this challenge for quality improvement. MAH caused neither mortality nor morbidity in this centre. In addition, bleeding as a risk factor had been reduced to 0% mainly by the analysed approach in co-ordination with haematologist, anaesthesiologist, perfusionist and surgeon. Another highlighting feature was early detection and correction of metabolic and electrolyte imbalances.

Follow up

Although MAH were causes for mortality and morbidity in the First phase, they did not contribute to mortality and morbidity in the other phases. After surgery children returned to the same impoverished environment with no way of improving their nutrition. Yet they came for review with a steady increase in height and weight. However they had not reached normal values of height and weight per age according to Indian standards except in 5 children. There are studies that have shown only increase in follow up weight and not in height [9]. There is one study in which malnourishment was not associated with mortality [6]. There are studies that optimise nutritional level prior to surgery [10]. We have not been able to do that due to practicalities.

Postoperative respiratory infection

Even when preoperatively respiratory infection was monitored with Total WBC Count, Differential count, blood smear, CRP levels, Skiagram Chest PA view and treated accordingly, Postoperative Respiratory infection did occur (2.73%) although it has become mild now. It is contributing to morbidity. We are trying to analyse other methods of management to reduce it still further.

Other risk factors

Risk factors that contributed to the outcome in the three were as per age, weight, RACH1 classification, (differences in morphology, surgical techniques adopted), Preoperative Hb and PCV, cyanotic spells, residual VSD and RVOTO, CPBP time, ACC time, RV outflow Patch Cardioplegia time, Cardioplegic solution type, Temperature, Hemofilter, negative fluid balance, RV function [20], mechanical Ventilation time, bleeding, reoperation, arrhythmia, metabolic and electrolyte imbalances ionotropics time and Postoperative respiratory infection.

Out of the above the most important were the RACH1 category 2, morphology and surgical technique of repairing them, long CPB and ACC times, myocardial protection, RV outflow patch and RV function.

Limitations of the Study

Since it is a retrospective analysis, data were incomplete in some areas. Diagnostic facilities available in the latter part of the First phase, second and third phases were not available in the earlier part of the first phase. Conclusions drawn were from available data. Further studies especially on follow up are essential. Increase in both height and weight during the follow up have to be evaluated.

Conclusion

MAH in the early phases contributed to postoperative mortality. (AH) when managed pre-intra and post operatively did not contribute to mortality or morbidity. On follow-up, 5 reached normal values of weight and Height as per age after 3 to 6 years. Although others increased in height and weight, did not reach normal values. Combination of State-Of-Art Infrastructure, Dedicated, trained team and hospital with multi-specialities in paediatrics play many important role in the outcome.

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