Managing CHD in tertiary NICU in collaboration with a cardiothoracic centre

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Research Article

Keywords: Congenital heart disease, non-cardiac tertiary NICU, paediatricians with expertise in cardiology

Posted Date: June 22nd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1741684/v1

Abstract

Purpose: Increasingly non-cardiac tertiary neonatal intensive care units (NCTNs) manage newborns with CHD prior to planned transfer to specialist cardiac surgical centres (SCSC). It improves patient flow in SCSCs, enables families to be nearer home, and improves psychological well-being[1]. This practice has gradually increased as the number of SCSCs has decreased. This study examines the effectiveness of this expanding practice. The management provided, length of stay and outcomes are described for one UK NCTN situated at a significant distance from its SCSC.

Methods: A retrospective observational study of cardiac-related admissions to a NCTN between January 2010 and December 2019 was conducted.

Results: 190 neonates were identified: 41 had critical CHD; 64 had major CHD. The cohort includes babies with a wide range of cardiac conditions and additional complexities. 23.7% (n=45) required transfer to a specialist centre after a period of stabilisation and growth ranging from several hours to 132 days. 68% (n=130) were discharged home or repatriated to a local NICU. Of the remaining 15 babies, 13 were transferred to other specialties including the hospice. Two died on NICU.

The mortality was consistent with the medical complexity of the group[2,3]. 8.9% (n=17) died before age 2. Nine babies had care redirected due to an inoperable cardiac condition or life-limiting comorbidities.

Conclusion: Our study demonstrates a complex neonatal cohort with CHD can be managed effectively in a NCTN, supporting the current model of care. The NCTN studied was well supported by paediatricians with expertise in cardiology alongside visiting paediatric cardiologists.

Key Messages Of Article

"What is known"

- Practice has evolved over the last three decades with babies increasingly cared for in NCTNs without co-located SCSCs.
- While management in NCTNs is well-established, published data for its efficacy is scarce. Outcomes for *carefully selected* patients delivered outside a SCSC has previously been shown to be safe[17].

"What is new"

- This service review looks at a large, complex cohort of babies, demonstrating high quality care can be provided at a distance from a SCSC.
- This provides evidence that babies with CHD and complex needs can be stabilised and managed for a significant length of time in a NCTN with good support from PECs and visiting paediatric cardiologists.

Introduction

The incidence of congenital heart disease (CHD) is ~5.6 per 1,000 live births in the UK[4]. Improvement in foetal anomaly screening and postnatal pulse oximetry screening have improved detection rates of neonatal CHD[5].

There have been significant improvements in surgical outcomes and survival, contributing to increased bed pressures in SCSC across the UK. Between 2011 and 2012, a total of 91000 days of inpatient care were spent on children with CHD[4], representing 1.5% of inpatient days in England. Consequently, there is an increasing practice of delivering and initially managing babies in non-cardiac tertiary NICU (NCTN). There are several other driving factors for this: (1) National Health Service (NHS) England aiming to provide high quality healthcare to children with CHD near home[5]; (2) the emergence of paediatricians with expertise in cardiology (PECs)[5]; (3) close collaboration between neonatologists, PECs and paediatric cardiologists.

Current evidence suggests better outcomes when newborns with an antenatal diagnosis of HLHS or TGA are delivered in the nearest SCSC[6,7]. A neonate with TGA may require urgent balloon atrial septostomy (BAS); an adequate interatrial communication cannot be reliably predicted antenatally[7,11]. The improvement in antenatal diagnosis has allowed tailored perinatal management plans[8-10], including identification of babies who can be safely managed in a NCTN.

The UK NCTN in this study has observed an increasing number of babies with antenatal and postnatal cardiac diagnoses being managed over the last ten years. These included critical CHD, defined as requiring intervention or resulting in death within 28 days of life[11] and major CHD, requiring intervention or resulting in death within the first year of life[11]. This NCTN has developed a pathway of care from antenatal diagnosis to post operative follow up (figure 1).

Babies with cardiac diagnoses often have complex needs requiring support for both cardiac and non-cardiac reasons whilst awaiting definitive cardiac intervention. Neonates with CHD tend to have significantly lower birth weights[12]. Recent studies[13-15] have suggested higher mortality amongst VLBW (<1.5kg) and LBW (<2.5kg) infants with significant CHD. Furthermore, severe CHD is independently associated with increased necrotising enterocolitis (NEC) risk[16]. Therefore, many preterm and VLBW neonates require careful medical management and growth optimisation in a NCTN before cardiac interventions.

While management in NCTNs is well-established and continues to increase, published data for its efficacy is limited[17]. The aim of this study is to review the complexity, management and outcomes of neonates with CHD managed in a UK NCTN working in close collaboration with paediatric cardiologists.

Methods

We conducted a single-centre, ten-year retrospective observational study on babies with cardiac conditions managed in a UK regional NCTN, between Jan 2010 and Dec 2019. The centre in question is situated at a significant distance from a SCSC. Cases were identified from our cardiac database. Data was obtained from hospital electronic records and Badgernet (national neonatal database). We reported their birth weight, gestational age, comorbidities, cardiac diagnoses, treatments and outcomes.

Neonates with mild CHD not requiring intervention who were discharged back to a local NICU were not included on our database and so not included in this study. Additionally, babies on our database with isolated PDAs and small inter-atrial communications that were largely related to prematurity were excluded.

Statistics:

The demographics were analysed for normality using Shapiro-Wilk test. Mean with standard deviation and median with interquartile range were quoted for parametric and non-parametric data, respectively. The Kruskal-Wallis test was used for non-parametric analyses. Wilcoxon signed-rank test compared the paired data to determine the significance of birth weight variances between babies of <28 weeks and other gestational age groups.

Results

A total of 200 neonates cared for on our NCTN between 2010 and the end of 2019 were identified as having had cardiac diagnoses; 10 were excluded as had isolated PDAs or small interatrial communications only. Of the 190 patients, 98 (51.5%) were male. 172 were in-born in the tertiary maternity unit with the remaining transferred from other neonatal units or in one case following a home delivery. Thirty-eight with stable conditions were managed on the postnatal ward without being separated from their mother.

109 (57.4%) of this cohort had an antenatal cardiac diagnosis with two found to have significant additional cardiac diagnoses postnatally.

Non-cardiac characteristics of the babies managed

The babies in this cohort included those with complex needs in addition to cardiac diagnoses. Table 1 summarises gestation, birth weight and comorbidity data, illustrating the complexity of this cohort. Eleven percent were either very (28-31^{+6}/40 weeks) or extremely (<28/40) preterm and were also of very (1-1.5kg) or extremely (<1kg) low birth weight. Forty-four (24%) had identifiable genetic abnormality. Of 190 babies, 38 had no additional medical genetic diagnosis identified apart from prematurity and low birth weight.

Table 1 Baseline characteristics of babies within cohort. **Table 1a** shows the range of birth weights found in the babies with cardiac conditions admitted to the unit. *Wilcoxon pairwise test was used to compare

the significance of birth weight variances between babies of <28 weeks and other gestational age groups. **Table 1b** summarises the co-morbidities [f] in () showed number who had surgical intervention; * in () showed number of sepsis which was severe. *CDH* congenital diaphragmatic hernia *CLD* chronic lung disease *HIE* hypoxic ischaemic encephalopathy *RDS respiratory distress syndrome PCD primary ciliary dyskinesia PIE* pulmonary interstitial emphysema

Table 1a Gestational age, sex and birth weight distribution

Variables	N (male)	Mean (range)/Median (IQR)		P values*
Birth weight, kg				
<1	11 (5)	0.77 (0.55-0.99)		
1-1.5	10 (4)	1.19 (1.02, 1.5)		
1.5-2.5	33 (15)	2.2 (1.94, 2.33)		
>2.5	125 (69)	3.31 (2.85, 3.71)		
Gest. age (weeks)	**χ^2(1, N=179) =0.715, p=0.87**		**Birthweight (kg)**	
< 28	7 (4)	26.64(25.93, 27.75)	0.8(0.64,0.98)	-
28 – 31^{+6}	13 (7)	30(28-31.86)	1.22(0.55-2.53)	0.13
32 – 36^{+6}	27 (14)	34.84(30.71-36.86)	2.15(0.99-2.85)	<0.05
³37	132 (70)	38.71(38,39.64)	3.30(2.8,3.65)	<0.001

Table 1b Other comorbidities

Co-morbidity	N
Trisomy 21	18
Other trisomies (T18/T13)	4
Genetic syndromes Noonan/Di George/CHOPS/MIDAS/Tuberous Sclerosis /Smith Magendi/VACTERL/CHARGE/Schuurs-Hoeijmakers /craniofacial microsomia	17
Unnamed genetic abnormalities found on microarray	5
Significant gastrointestinal Hirschsprung/duodenal atresia/malrotation/pyloric stenosis/imperforated anus	23 (8)[f]
Renal/genitourinary Hydronephrosis/renal agenesis/hypospadias	11
Neurology HIE/ventriculomegaly/meningocele/vein of Galen	8 (1)[f]
Ear, nose, throat cleft lip/cleft palate/choanal atresia/tracheal stenosis/laryngeal cleft/laryngomalacia	11
Respiratory (RDS/PIE/CLD/bronchomalacia/pneumothorax/CDH/lung hypoplasia/PCD/scimitar	26
Sepsis	19 (1)*
Other Feeding problems /Jaundice /Hypoglycaemia/ Twin to twin transfusion/Neonatal lupus	17

Cardiac diagnoses of the babies managed

A broad range of cardiac conditions and severity were managed. Forty-one (21.6%) of the 190 babies had critical CHD. Sixty-four (33.7%) had major CHD (figure 2).

The cardiac conditions varied in complexity. These were classified as (table 2): complex cyanotic or acyanotic, moderate, mild, heterotaxy, cardiomyopathies, cardiac tumours, vascular anomalies and arrhythmias. 50.5% had a diagnosis of complex CHD and ~50% of these had a cyanotic lesion. Forty-one (21.5%) had duct-dependent conditions requiring Prostaglandin (PGE_2) treatment. Of these, 6 were functionally univentricular hearts.

Management

The babies in this cohort received a variety of treatments on the NCTN. A number required ventilatory and feeding support due to prematurity and other comorbidities (table 1); 21 (11%) were intubated and ventilated and 35 (17.7%) required central line insertion. Nine had non-cardiac surgical procedures.

Two were diagnosed postnatally with TGA needing urgent BAS on NCTN by SCSC paediatric cardiologist. The third TGA case was one whose birth had been planned at a SCSC, but delivered unexpectedly at NCTN and had good atrial mixing, not requiring BAS.

Table 2 illustrates the diagnoses range and the numbers of babies falling into each diagnostic category. *AR* aortic regurgitation; *AS* aortic stenosis*; ASD* atrial septal defect; *AVSD* atrioventricular septal defect; *CHB* complete heart block *CHD* congenital heart disease; *BAV* bicuspid aortic valve; *DORV* double outlet right ventricle; *incl.* including; *MR* mitral regurgitation; *MS* mitral stenosis; *PDA* patent ductus arteriosus; *PHT* pulmonary hypertension; *PPHN* persistent pulmonary hypertension of newborn; *PR* pulmonary regurgitation; *PS* pulmonary stenosis pulmonary stenosis; *TR* tricuspid regurgitation; *VE* ventricular ectopic; *VSD* ventricular septal defect; *SV* single ventricle; *TAPVC* total anomalous pulmonary venous connection; *TGA* transposition of great arteries. * number of children with severe cyanotic CHD included in either the cyanotic and acyanotic category.

Diagnostic category	Cardiac diagnoses	N	Joint/Main diagnoses (N)
Complex CHD			
1. **Cyanotic**	1. TGA	4	50 (6) *
	1. Tetralogy of Fallot (incl. pulmonary atresia and absent pulmonary valve)	19	
	1. Hypoplastic right heart	2	
	a. Tricuspid atresia	1	
	b. Pulmonary atresia with intact interventricular septum	1	
	1. Hypoplastic left heart syndrome	8	
	a. Aortic atresia	2	
	b. Mitral atresia	4	
	c. Criss-cross heart	1	
	1. Severe Ebstein anomaly	5	
	1. DORV	11	
	1. Truncus arteriosus	1	
	1. TAPVC	2	
	1. Critical or severe PS	3	
2. **Acyanotic**	1. AVSD	19	52 (6) *
	1. Large VSD (not incl. those accounted for as part of a cyanotic lesion – i.e. DORV/ tetralogy)	13	
	1. Critical/severe AS or AR	3	
	1. Critical coarctation of the aorta or aortic arch abnormality	17	

	1. Congenitally corrected TGA	3	
	1. Pulmonary vein stenosis	3	
Moderate CHD	1. Mild/mod AS/AR	2	25
	1. Moderate PS/PR	9	
	1. Non-critical coarctation or arch abnormality	15	
	1. Large ASD	10	
	1. Complex VSD	3	
Mild CHD	Small VSD/ PDA / Mild PS / BAV w/out AS or AR / small ASD / mild to moderate TR/MR/MS	158	24
Rhythm disturbances	Incl. SVT, incl. atrial tachycardia, runs of VE's, CHB	20	18
Vascular anomalies	Incl. vascular rings, double aortic arches	26	18
Cardiomyopathies/PHT	Cardiomyopathies, PPHN	5	3
Heterotaxy syndrome	Dextrocardia, left atrial isomerism, abdominal situs inversus	9	4
Cardiac tumours	Rhabdomyomas	2	2

Ninety-five (50%) of the total cohort required an operative or percutaneous intervention at a SCSC and 15 received more than one such intervention (figure 3a).

Figure 3b shows the range of cardiac medications prescribed. Around 10.5% required diuretics for treatment of heart failure. One fifth (n=41) had a duct-dependent CHD commenced on PGE_2. Five had PGE_2 discontinued within 24 hours due to: (1) anomaly less significant on postnatal echo (n=2) and (2) adequate central mixing (n=3). Median length of PGE_2 therapy was 3 days ranging from a few hours to 30 days for those with right heart obstruction and up to 50 days for left heart obstruction (figure 3c). The longest duration of prostin therapy was 50 days for a baby weighing 0.995kg at birth with coarctation of the aorta (figure 3c).

Twenty babies presented with arrhythmias; 17 required antiarrhythmic therapy. All neonatal arrhythmias were managed in the NCTN with SCSC advice. The majority had supraventricular tachycardia (SVT) while one had CHB and one had ventricular ectopic runs with trigeminy. Four were diagnosed antenatally with fetal tachycardia and two had hydrops fetalis, one of which required postnatal chest drain insertion. Eleven babies required adenosine for SVT medical cardioversion. Ten of these and six others

who did not require adenosine received maintenance therapy: 7 propranolol, 4 flecainide, 3 amiodarone, 2 amiodarone and propranolol. The baby with CHB secondary to undiagnosed maternal lupus was born at 28 weeks weighing 1.12kg, and required Isoprenaline infusions for 61 days prior to repatriation to local unit.

Length of stay data

The median length of stay (LOS) was 6 days (IQR 16; 3-19), the maximum stay was 184 days. The LOS for this cohort varied hugely dependent on comorbidities, birth weight, gestation and complexity of their cardiac condition.

56% (n=107) had stable in-patient course and were discharged home; 12% (n=23) were repatriated to another NICU nearer home. These children were subsequently followed up locally by PECs and SCSC paediatric cardiologists. Seven babies were discharged from NICU with palliative or supportive care plans without cardiac intervention offered; another two died following redirection of care on NCTN before discharge.

Forty-five (23%) infants had critical or major CHD necessitating transfer to a SCSC for active intervention after initial stabilisation in NICU. A small number needed transferring for ongoing non-cardiac specialist care: 4 babies were transferred to SCSC PICU for ongoing care, one of whom required a tracheostomy; two went for non-cardiac interventions, one of whom required vein of Galen malformation surgery which was unavailable at this NCTN and the other was considered high anaesthetic risk requiring a cardiac anaesthetist

Out of 145 who were not transferred to SCSC during their inpatient stay, 113 (78%) were discharged from the NCTN within 3 weeks (figure 4c). Of those (n=45) requiring transfer to a SCSC, 16 (35.6%) were transferred within 2 days of birth; 15 were stabilized and managed for between 3 days and 3 weeks and the final third needed a longer period of stabilisation and growth up to 132 days (figure 4d)

Mortality data

Seventeen children died before two years of age, reflecting the complexity of the caseload (figure 4b). Of the babies who died, three had inoperable cardiac conditions redirected to palliative care. Five others were redirected to palliative care due to co-existing syndromic diagnoses with poor prognoses; two of these babies had first been transferred to SCSC before the decision for palliation was made.

Two babies had care redirected on NCTN due to complex cardiac pathology, co-existing genetic diagnoses and a deteriorating clinical picture.

Of the seven babies that died post discharge from the unit, who were not under palliative care, one died following transfer to PICU for respiratory failure following long term ventilation and another in the SCSC

within a month following BT shunt insertion. Another died post discharge home from the SCSC following radiofrequency ablation for pulmonary atresia. The remaining four babies died of non-cardiac or unidentified causes, including sepsis and SIDS.

The mortality in this cohort by 2 years old is 8.9%. Importantly, no deaths were attributed to having been managed in a NCTN.

Discussion

Most newborns with severe CHD who once had a poor prognosis are now surviving with improved quality of life[18,19]. In addition, there has been a reduction in the number of SCSCs to create higher volume centres which may have further improved outcomes[20]. The result has been an increase in SCSC capacity demand. Increasing cardiac expertise in NCTN has allowed flexibility in SCSCs bed capacity management[19].

Surveys from families show an increase in expectations for care provision near home[1,21]. As a result, we have seen the emergence of PECs to provide such care in NCTNs[5]. This allows specialist outreach and care for families near home[1,5]. While this increase in care in NCTNs has evolved due to necessity and the desire to provide care closer to home, there is limited published evidence[17] of its efficacy prior to this study. This model of care should only be practiced in an NCTN collaborating with an SCSC, preferably within a network with shared guidelines and pathways[5].

In experienced hands, 50-60% of critical CHD is diagnosed antenatally[8-10]. Although most significant CHD can be managed in NCTNs, newborns with fetal diagnoses of TGA and HLHS for active management should be delivered in a SCSC[6,7] due to the potential necessity for emergency intervention. Fetal diagnosis enables safe planning for local management in NCTNs. The planning for significant CHDs in our NCTN involves a multidisciplinary team: a paediatric cardiologist, PECs, fetal obstetricians, neonatologists and midwives. Parents are counselled and a detailed birth and postnatal plan is made and shared with the parents and all professionals.

Preterm infants with CHD and additional congenital anomalies are now more likely to survive[18,19,22], albeit with variable morbidity[23-25]. This poses a challenge to NCTNs to provide high-quality neonatal care to an increasingly complex group of preterm infants with CHD, who are at additional risk from LBW or IUGR, and at increased risk of NEC and CLD[13-16]. These babies can benefit from early specialised care from a multidisciplinary team experienced in neonatal care[16,26], some of whom will provide on-going long-term care.

Our study demonstrates that babies with CHD and additional complexities of prematurity, low birth weight and comorbidities can be safely managed in a NCTN. Our cohort includes a breadth of gestational ages and birth weights with the most preterm born at 25 weeks and the lowest birth weight being 550g. In addition, the population had significant comorbidities (table 1). Nine babies required other non-cardiac

surgical interventions, which were safely managed in the NCTNs by paediatric anaesthetists and surgeons (table 1b).

This retrospective review illustrates that active, non interventional CHD treatment can be delivered in an NCTN, in close collaboration with specialist cardiologists, to babies with CHD for whom births are carefully plannedin. This cohort included babies with a wide range of CHD, including those with critical (21.6%) and major (33.7%) diagnoses including functionally univentricular hearts. These babies were successfully managed on NICU close to home until specialist cardiac intervention was required. The study also highlights the importance of a safe and evidence-based approach[11]. Clear communication with paediatric cardiologists and the SCSC has allowed safe delivery and early transfer of duct-dependent CHD for direct SCSC input, with good survival outcomes. This was corroborated by the results where 75% of those requiring PGE_2 born at a weight allowing early interventions were transferred within 4 days, with all the TGAs transferred in <24 hours (36%) (figure 3c). Others were clinically stable but required a prolonged period of stabilization and growth at the NCTN. In our cohort, all PGE_2 was safely administered through central venous catheters. All babies with neonatal arrhythmias were initially managed in the NCTN with SCSC input.

The duration of each stay in NCTN will vary, depending on other co-existing medical conditions, availability of local resources, and level of support from PECs and SCSC paediatric cardiologists. This variability was seen within our cohort with a length of stay ranging from a few hours to 184 days with a median of 6 days.

The safe and effective management of this cohort is reflected in the mortality outcomes. In one meta-analysis, a pooled 1-year survival for babies with CHD was calculated at 87%[2]. Mortality in the first year of life in a French cohort was found to be 17.9% in preterm infants with CHD and 4.7% for term infants[3]. Seventeen (8.9%) of the children in our complex caseload died before they were two years old. Nine babies had their care redirected to palliative care services. Of these, all but two avoided a transfer to the SCSC. Instead, a family-centred end-of-life care with input from the Hospice and their symptom management team was facilitated. The support of a visiting paediatric cardiologist cannot be underestimated, providing additional guidance to families in decision-making process around all aspects of management, including the decision of redirection to supportive palliative care.

Lastly, children with complex CHD often have additional complex needs on discharge requiring multidisciplinary input from community paediatricians, dietitians, speech and language therapists, physiotherapists, occupational therapists, psychologists, specialised immunisation clinics, gastrostomy nurse specialists and child developmental centre facilities[4,5,21,27]. This complex discharge planning can be better organised if children have been introduced to their local teams at the earliest opportunity[21]. The NCTN in this study has established neonatal community and cardiac outreach specialist nursing care pathways following discharge to conduct home surveillance monitoring to further support the CHD population.[17,28,29]

Conclusion

There has been a significant improvement in the outcome and survival of children with CHDs reflecting medical and surgical achievements. This poses new challenges to cardiology services and care in NCTNs has had to expand significantly. There is limited published data to date supporting this practice. Our study demonstrates that high quality care can be safely provided to highly complex babies with CHD in a NCTN supported by PECs working closely with paediatric cardiologists, therefore reducing the pre operative LOS in the SCSC. Such an approach requires careful planning with clear communication amongst the multidisciplinary team.

Abbreviations

BAS	Balloon atrial septostomy
CCHD	Critical congenital heart disease
CHD	Congenital heart disease
CLD	Chronic lung disease
HLHS	Hypoplastic left heart syndrome
IUGR	Intrauterine growth restriction
LBW	Low birth weight
LOS	Length of stay
NCTN	Non-cardiac tertiary NICU
NEC	Necrotising enterocolitis
NICU	Neonatal intensive care unit
PEC	Paediatrician with expertise in cardiology
PGE_2	Prostaglandin E_2
PICU	Paediatric intensive care unit
SCSC	Specialist cardiac surgical centre
TGA	Transposition of great arteries
VLBW	Very low birth weight

Declarations

Contributorship Statement: Dr W Kelsall is responsible for the initial concept and design for this work; Dr YH Chee and Dr B Dunning-Davies were involved with the design and also responsible for the acquisition and interpretation of data and drafting of the manuscript; Dr R Yates and Dr Y Singh contributed to the conception and design of the work. All authors were involved in revisions and final approval of the work and agree to be accountable for all aspects of the work in ensuring that any questions pertaining to the accuracy or integrity of the work would be properly investigated and resolved.

Conflicts of interest/Competing interests: I declare that the authors have no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper.
Availability of data and material: (data transparency) N/A If further information is required, data can be supplied in an anonymized format.
Code availability: N/A
Ethics approval: N/A The study was checked on the NHS REC committee decision tool and the advice was that ethics approval was not required.
Consent to participate: N/A
Consent for publication: All authors consent to the publication of this paper.

Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

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Figures

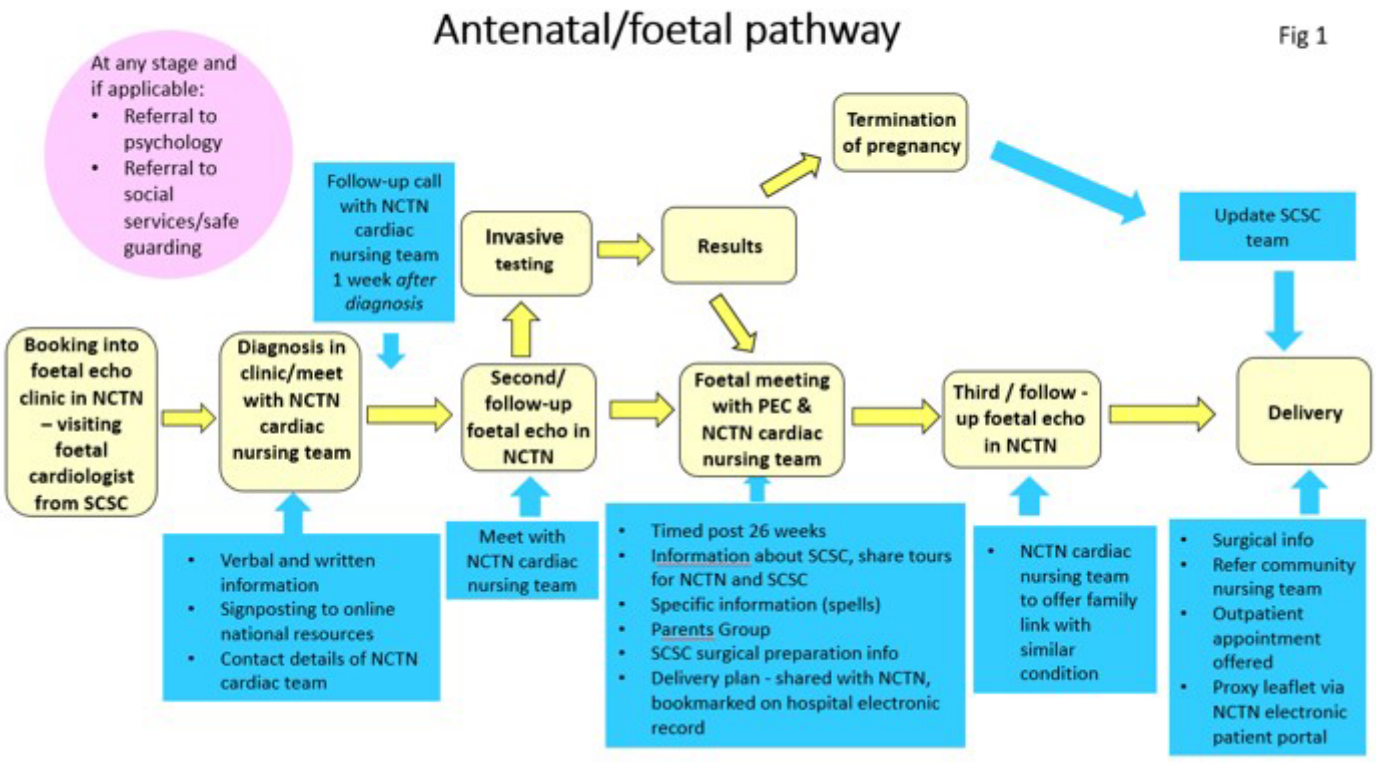


Figure 1

demonstrates the care pathway from antenatal diagnosis to post operative care developed in this NCTN.

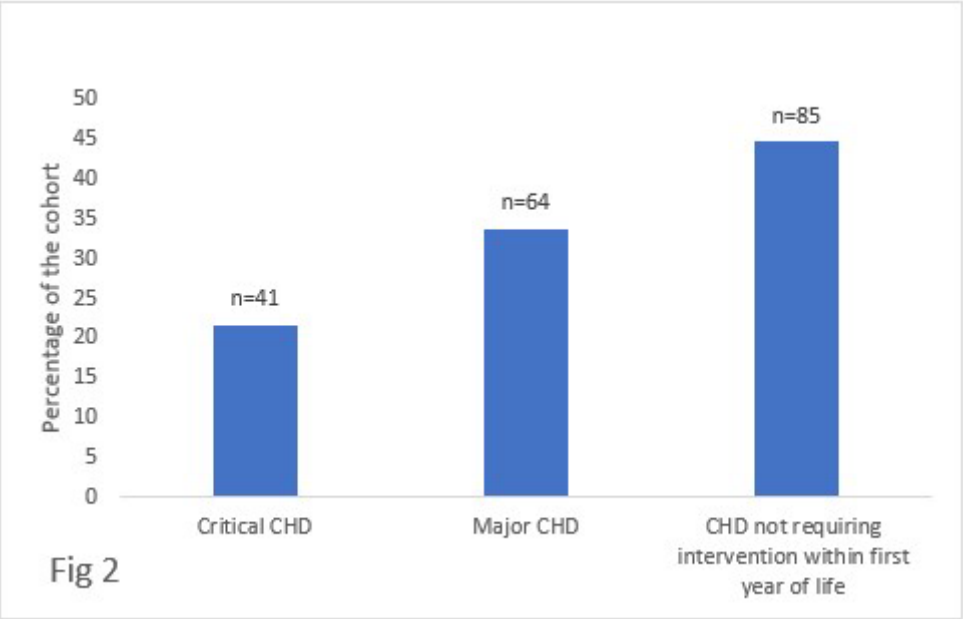
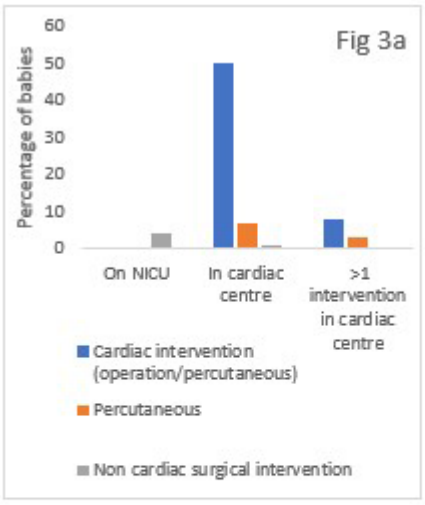
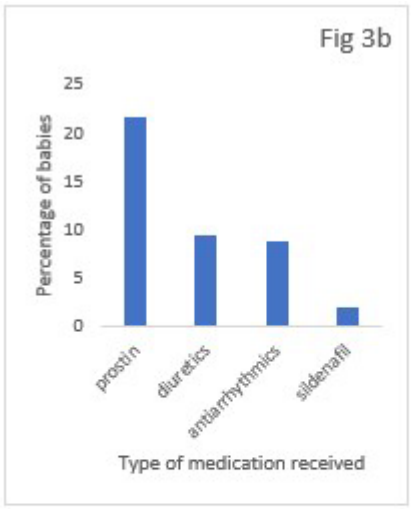


Figure 2

shows the percentage of children with major versus critical congenital heart disease managed on the unit. The bar on the far-right showed the number of babies with CHD not requiring intervention within the first year of life.





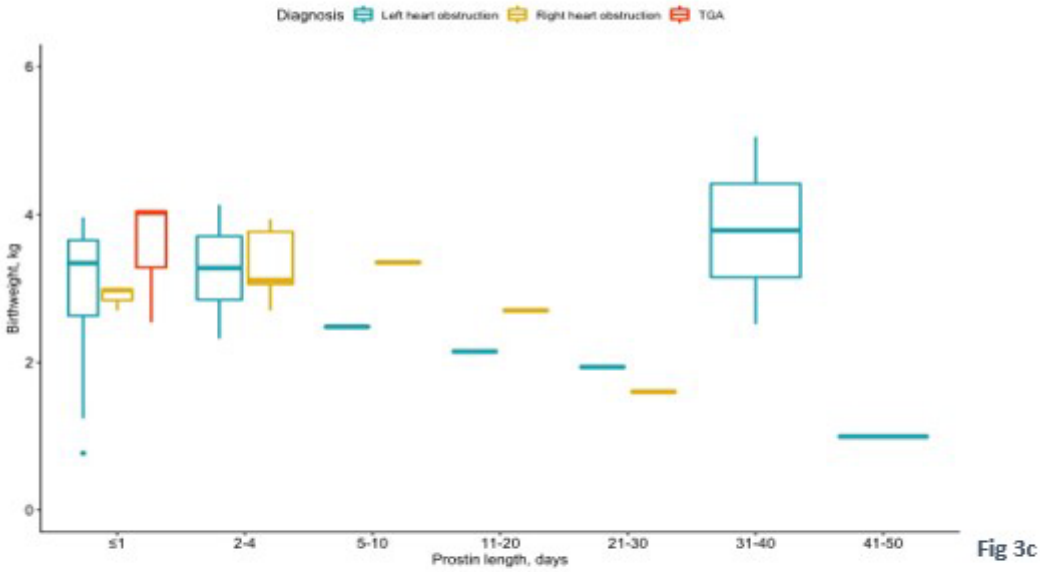
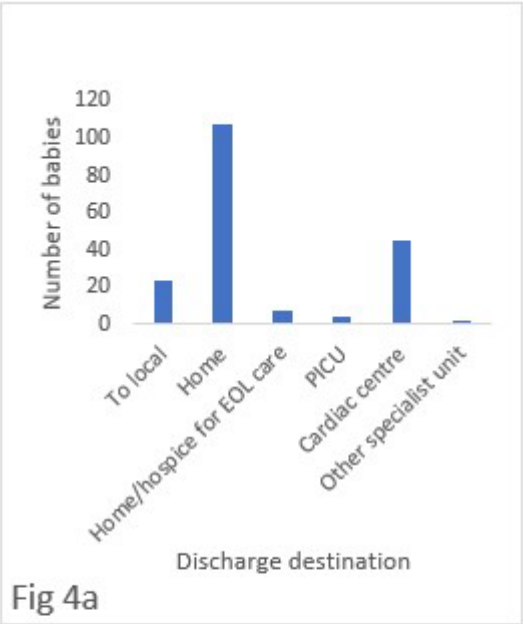


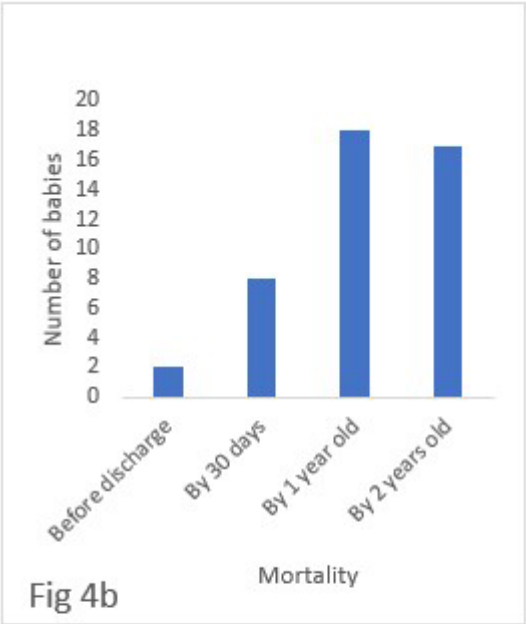
Fig 3c

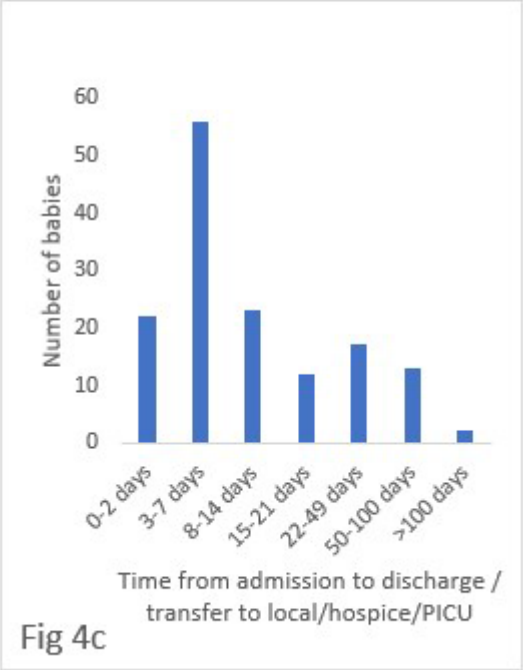
Prostin therapy length, days	N	Required for:			Birth Weight range, kg
		Left heart obstruction	Right heart obstruction	TGA	
≤ 1	15	9	3	3	0.77 to 4.05
2-4	16	9	7	0	2.32 to 4.13
5- 10	2	1	1	0	2.48 to 3.35
11-20	2	1	1	0	2.15 to2.7
21-30	3	1	1	0	1.6 to 1.935
31-40	2	2	0	0	2.52 to 5.05
41-50	1	1	0	0	0.99

Figure 3

Treatments received by babies with CHD. **Figure 3a** shows the number of babies who received cardiac medications whilst on the unit. **Figure 3b** shows the number of babies who required surgical or percutaneous interventions for their cardiac condition and non-cardiac conditions and the unit where these were performed. **Figure 3c** shows the differing lengths of 'prostin' therapy delivered on the NSCC NICU and the diagnostic groups for which it was given. *TGA* transposition of great arteries.







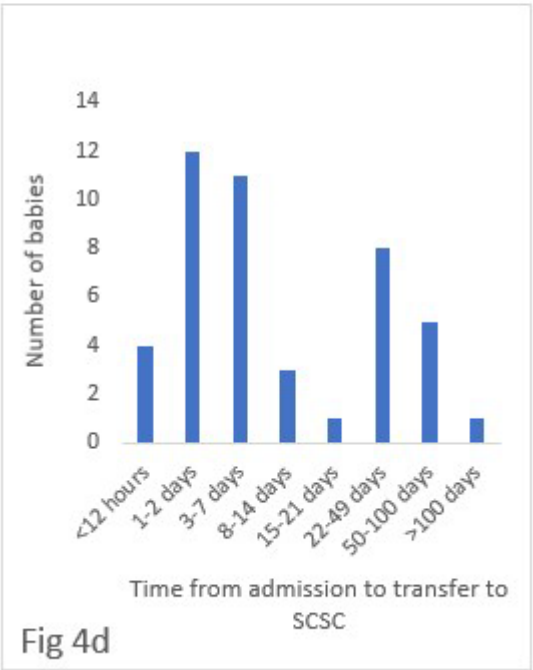


Figure 4

summarises the outcome data for children with cardiac conditions treated on the unit. **Figure 4a** shows the discharge destinations following initial NICU stay. **Figure 4b** illustrates the mortality data; the “before discharge” category includes those dying before discharge from the NCTN as opposed to prior to discharge home. **Figure 4c** shows the length of stay of babies cared for on the unit and did not require transfer on to a cardiac specialist centre. **Figure 4d** shows the length of stay for the babies who required inter-hospital transfer to a specialist cardiac centre for review and or intervention.