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ORIGINAL RESEARCH

Disease spectrum and short-term outcomes of obstetric patients with cardiac disease admitted to an obstetric critical care unit in South Africa

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Background: Cardiac disease in pregnancy is a leading, indirect cause of maternal mortality. The disease spectrum differs between high-, middle-, and low-income countries. We describe the disease spectrum and short-term in-hospital outcomes in obstetric patients with cardiac disease at an obstetric critical care unit (OCCU) in an upper middle-income country (UMIC).

Methods: A single-centre, descriptive, historical cohort study was performed of all the obstetric patients with cardiac disease admitted between January 2018 and December 2019 to the Tygerberg Hospital (TBH) OCCU (n = 86) in Cape Town, South Africa (SA). We analysed groups according to the Cardiac Disease in Pregnancy (CARPREG) II and modified World Health Organization (mWHO) risk assessment tools.

Results: Three main groups were identified: valvular heart diseases (50%), cardiomyopathy (22%), and congenital heart disease (21%). The majority (88%) of 34 adverse cardiac outcomes occurred with cardiomyopathy and valvular disease. CARPREG II echocardiography high-risk parameters depended on the cardiac class: cardiomyopathy and valvular disease had a higher association ($p < 0.001$). Cardiac interventions were performed in 30 patients before pregnancy: 17 valvular, 12 congenital, and one Takayasu's arteritis. Three interventions were performed during pregnancy and none postpartum. Peripartum OCCU interventions (ventilation and vasoactive support) were exclusively required by patients with cardiomyopathy (n = 12) and valvular disease (n = 11). Patients presenting with pulmonary oedema (p = 0.035) and needing ventilation (p = 0.027) or vasoactive support ($p < 0.001$) had longer OCCU stays.

Conclusion: Patients admitted to the OCCU with cardiac disease in obstetrics had mainly valvular heart disease, cardiomyopathy, and congenital heart disease. Adverse cardiac outcomes were associated with cardiomyopathy and valvular disease. Although SA is classified as an UMIC, our disease spectrum was more representative of a low- to middle-income country (LMIC). Patients with previous cardiac interventions had fewer adverse cardiac outcomes and booked earlier. The length of stay was longer when patients presented with pulmonary oedema and needed ventilation and vasoactive support.

Keywords: cardiac disease, CARPREG II risk score, echocardiography, lower middle-income countries, obstetric critical care unit

Introduction

Cardiac disease in the obstetric population differs between high-income countries (HICs), upper middle-income countries (UMICs), and low- to middle-income countries (LMICs).[1-3] Whereas congenital heart disease predominates in HICs, rheumatic heart disease tends to predominate in LMICs and some UMICs, such as Brazil.[2-6] The relative prevalence of congenital and rheumatic heart disease is quite variable in UMICs. The aforementioned prevalence is relatively similar in the Philippines, whereas limited information from a single tertiary hospital in South Africa (SA) suggests that congenital heart disease is predominant.[1,7] Although SA is classified as an UMIC, there are many resource-limited environments outside the tertiary referral centres.

In SA, the most common indirect cause of death during pregnancy remains non-pregnancy-related infections, the majority related to human immunodeficiency virus (HIV).[1,8,9] This is followed by medical and surgical conditions, contributing to 13.5% of all maternal deaths, with cardiac disease comprising 32.7% of this group.[1,8] A delay in seeking medical care, including late antenatal booking, stands out as a major contributor to maternal cardiovascular mortality in resource-limited environments.[2,10]

The increased prevalence of cardiac-obstetric patients has led to the development of cardiac-obstetric clinics at tertiary hospitals in SA.[1] At Tygerberg Hospital (TBH), a tertiary hospital in the Western Cape province of SA, peripartum management of selected high-risk pregnant patients is undertaken in a dedicated obstetric critical care unit (OCCU). This unit is set up according to the International Federation of Gynaecology and Obstetrics (FIGO) blueprint and has demonstrated a decrease in maternal mortality.[11,12]

Risk-scoring tools may be helpful in predicting and managing cardiac-obstetric complications. In the CARPREG II study (1 938 patients), most cardiac events occurred antenatally (64%), or postpartum after discharge (32%), with 4% occurring

peridelivery.[2] Silversides et al. conducted their study in two large Canadian tertiary hospitals and suggested the need for more studies in resource-limited environments using the CARPREG risk tool to assess its generalisability.[2] Suwanrath et al. concluded that the mWHO classification is valuable for predicting maternal as well as fetal outcomes in pregnant women with cardiac disease, especially congenital heart disease, but lacked validation studies for acquired diseases like rheumatic heart disease, which is prevalent in LMICs.[13]

Given the limited availability of critical care and resources in hospitals, assessing the burden of disease in cardiac-obstetric patients is important.[14] Uebing et al. emphasised the value of a multidisciplinary team managing these patients.[15] Assembling a multidisciplinary team, including a cardiologist, obstetrician, and anaesthetist, we decided to review the spectrum of cardiac disease in peripartum patients admitted at TBH and their short-term outcomes over two years.

Methods

A single-centre, descriptive, historical cohort study was performed. The primary outcomes of this study included 1) an assessment of the spectrum of cardiac pathology in this patient population, as shown by their latest echocardiograms; 2) the short-term in-hospital outcomes of obstetric patients with cardiac disease admitted to the OCCU during the peripartum period, including primary and secondary cardiac outcomes according to CARPREG II; 3) the cardiac and critical care interventions (ventilation and vasoactive support) needed; and 4) whether any significant differences existed in the length of OCCU stay amongst the patients from different disease classes. The secondary outcomes were to assess 1) the differences in CARPREG II and mWHO risk scores between the classes; 2) the mode of delivery; 3) the anaesthesia provided; and 4) neonatal outcomes.

Ethical clearance was obtained from the Stellenbosch University Health Research Ethics Committee (ethics reference number S20/09/228), and the declarations of the Helsinki principles were upheld. A waiver of consent was obtained since the data was anonymised and deidentified.

All the obstetric patients with cardiac disease admitted to the TBH OCCU from 1 January 2018 to 31 December 2019 were included using the OCCU admission books. The two-year retrospective period of 2018–2019, before COVID-19, was suggested by the obstetrician in charge of the OCCU. OCCU admission criteria included patients requiring level 2 or 3 critical care, invasive and continuous monitoring, respiratory support, and haemodynamic support.[12] Cardiac complications secondary to preeclampsia were excluded since our focus was on primary cardiac pathology.

The data collected included:

- Age
- Gravidity and parity
- Relevant comorbidities
- Gestational age (GA) at initial presentation (divided into early and late bookers, where a late booker was defined as presenting after 24 weeks gestation)
- GA at OCCU admission
- GA at delivery
- Latest echocardiographic parameters
- Primary/secondary cardiac diagnosis
- Prior cardiac interventions, where applicable
- New York Heart Association Functional Classification (NYHA) at baseline in pregnancy as recorded during antenatal care and on admission
- Signs of cardiac failure, defined as pulmonary oedema, tachycardia (heart rate [HR] > 100), or maternal cyanosis confirmed by pulse oximetry < 90% saturation
- Presence of arrhythmias on admission and during the hospital stay
- mWHO risk classification (see addendum)
- CARPREG II high-risk score (see addendum)
- Specific echocardiographic high-risk parameters (according to the CARPREG II-risk tool)
- CARPREG II primary adverse cardiac outcomes (maternal death and cause, cardiac arrest, sustained arrhythmia requiring treatment, heart failure, stroke or transient ischaemic attack, thromboembolism, myocardial infarction, vascular dissection)
- Secondary cardiac outcomes (a decline in NYHA class of ≥ 2 during the antepartum period, need for an urgent invasive treatment procedure, surgery during pregnancy and up to discharge postpartum)
- Critical care outcomes (length of stay, need for ventilation, and need for vasoactive support)
- Mode of delivery
- Anaesthetic interventions
- Neonatal outcomes

Patients were grouped into four large categories according to pathology: valvular heart disease, cardiomyopathy, congenital heart disease, and other heart diseases. Echocardiography reports were analysed descriptively, documenting the prevalence of each specific condition and noting adverse outcomes.

Descriptive statistics such as means, standard deviations (SD), medians, frequencies, and percentages were compiled for the study overall and by the cardiac disease group. For the comparison of categorical variables across the cardiac disease group, chi-square and Fisher's exact tests were used. For continuous outcomes, analysis of variance (ANOVA) was used to compare means across the cardiac disease group. Analyses of the differences in length of stay in the intensive care unit (ICU) between cardiac disease classes and after a specific ICU intervention were done using Mann–Whitney or Kruskal–Wallis tests for non-parametric data.

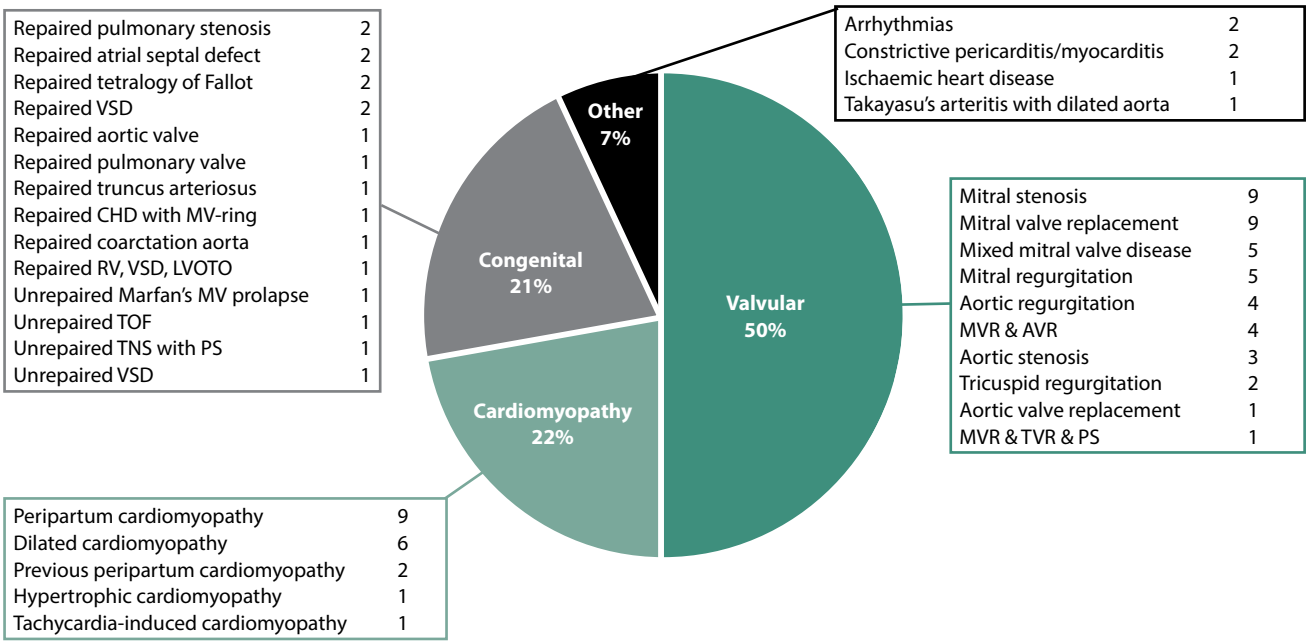

Figure 1: Spectrum of cardiac diseases identified for obstetric patients with cardiac disease ($n = 86$), as defined by their latest echocardiogram, cardiac complications secondary to preeclampsia were excluded as our focus was on primary cardiac pathologies
AVR – aortic valve replacement, CHD – congenital heart disease, LVOTO – left ventricular outflow tract obstruction, MV – mitral valve, MVR – mitral valve replacement, PS – pulmonary stenosis, RV – right ventricle, TNS – Turner Noonan syndrome, TOF – tetralogy of Fallot, TVR – tricuspid valve replacement, VSD – ventricular septal defect

Regression models were used to evaluate the association of baseline factors, including the cardiac disease group with the need for ventilation/ICU and the length of stay. For the categorical outcome, the need for ventilation, a logistic regression model was used, and odds ratios with 95% confidence intervals (CI) were estimated and reported. The utility of this model to predict the need for ventilation was evaluated, and the receiver operating characteristic curve (ROC) for the model was calculated. A robust quantile regression model was used to model the median days on the baseline factors for the length of stay. Median differences and 95% CIs were calculated and reported. A significance level of $p < 0.05$ was used. All analyses were done in Stata version 17, Microsoft Excel® 2019, and GraphPad Prism version 9.

Results

Over the two years, 86 patients were enrolled. The mean age (SD) in years was 29.3 (6.1). Median gravidity was 2.00, with an interquartile range (IQR) of 1.00–3.00, and median parity was 1.00 (0.00–2.00). The mean GA in weeks at presentation was 25.43 (10.11) (Table I). Of our patients, 63% ($n = 54$) were late bookers, 44% ($n = 38$) presented in the third trimester, 15% ($n = 13$) in the first trimester, and 40.7% ($n = 35$) in the second trimester, of which 22% ($n = 19$) were early and 18.6% ($n = 16$) late.

The pathology grouping comprised valvular heart disease ($n = 43$, 50%), cardiomyopathy ($n = 19$, 22%), congenital heart disease ($n = 18$, 21%), and other heart diseases ($n = 6$, 7%).

Peripartum cardiomyopathy, mitral valve replacement, and mitral stenosis (MS) were the most prevalent pathology in this cohort, followed by dilated cardiomyopathy (DCMO) and other valvular diseases (Figure 1). Mitral valve disease with or without aortic involvement comprised 38.4% of the patients. For two patients, a formal echocardiography report was not available; these two were excluded whilst analysing the echocardiographic high-risk parameters but included in analyses where these high-risk parameters were not correlated.

Regarding short-term in-hospital cardiac outcomes, 88% of 34 primary and secondary cardiac outcomes were associated with valvular disease and cardiomyopathy (Table II). The profiles of primary cardiac outcomes were significantly different between the four cardiac disease groups ($p = 0.025$). The congenital group had no primary cardiac events (0/18), whereas the cardiomyopathy group had the highest occurrence (9/19, 47%), followed by the valvular group (11/43, 25.58%). Overall, 25% of participants had a cardiac event. Secondary cardiac events did not differ across the cardiac disease groups ($p = 0.096$).

There were two mortalities in the cohort. One presented with DCMO and septic shock due to an ileocaecal perforation after her caesarean section (CS). This was further complicated by acute kidney injury (AKI) and ongoing sepsis. This patient was also an outlier regarding the length of stay (19 days). The second patient presented at 25 weeks GA with acute cardiac failure secondary to severe MS with pulmonary hypertension, possibly precipitated by active pulmonary tuberculosis and AKI. She had no prior cardiac intervention, a mWHO risk score of IV and a CARPREG II risk score > 4. She presented in extremis and had a cardiac arrest on arrival, for which unsuccessful cardiopulmonary resuscitation was performed.

There were 30 (34.8%) patients who had a pre-pregnancy cardiac intervention, including 17 (56.7%) valvular and 12 (40%) congenital disease, and one (3.3%) for Takayasu's arteritis. There were three interventions during pregnancy and no interventions

Table I: Univariate analysis of gravidity, parity, gestation at presentation, and length of stay

				Quantiles				
Variable	***n***	**Mean**	**SD**	**Min**	**25th**	**Median**	**75th**	**Max**
Gravidity	86	2.51	1.55	1.00	1.00	2.00	3.00	10.00
Parity	86	0.97	1.03	0.00	0.00	1.00	2.00	5.00
Gestation at presentation	86	25.43	10.11	4.00	17.00	26.00	34.00	40.00
Length of stay	86	4.10	4.78	0.15	2.00	3.00	5.00	37.00

SD – standard deviation

Table II: Cardiac group versus primary and secondary cardiac outcomes (*n* = 86)

	Cardiac group *n* (%)				
Primary cardiac outcomes (Fisher's exact test = 0.025)	**Cardiomyopathy (*n* = 19, 22%)**	**Congenital heart disease (*n* = 18, 21%)**	**Valvular heart disease (*n* = 43, 50%)**	**Other heart diseases (*n* = 6, 7%)**	**Total**
*Maternal death**	1 (5.26)	0 (0.00)	1 (2.33)	0 (0.00)	2 (2.33)
Cardiac arrest	1 (5.26)	0 (0.00)	1 (2.33)	0 (0.00)	2 (2.33)
Cardiac failure	5 (26.32)	0 (0.00)	7 (16.28)	0 (0.00)	12 (13.95)
Cardiac thromboembolism	2 (10.53)	0 (0.00)	2 (4.65)	0 (0.00)	4 (4.65)
Sustained arrhythmia requiring treatment	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	1 (1.16)
Vascular dissection	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	1 (1.16)
None	10 (52.63)	18 (100.00)	32 (74.42)	4 (66.67)	64 (74.42)
Total	19 (100.00)	18 (100.00)	43 (100.00)	6 (100.00)	86 (100.00)
Secondary cardiac outcomes (Fisher's exact test = 0.096)					
Decline in NYHA class > 2	3 (15.79)	0 (0.00)	6 (6.98)	0 (0.00)	9 (10.47)
Need for urgent invasive treatment procedure	0 (0.00)	1 (5.56)	1 (2.32)	1 (16.67)	3 (3.49)
None	16 (84.21)	17 (94.44)	36 (86.05)	5 (83.33)	74 (86.05)
Total	19 (100.00)	18 (100.00)	43 (100.00)	6 (100.00)	86 (100.00)

NYHA – New York Heart Association Functional Classification
* Maternal death during hospital stay.

Table III: Relationship between the cardiac group and CARPREG II echo high-risk parameters[2]

	Cardiac group *n* (%)				
High-risk on echocardiography	**Cardiomyopathy**	**Congenital**	**Valvular**	**Other**	**Total**
Yes	18 (94.74)	6 (37.50)	35 (81.40)	3 (50.00)	62 (73.81)
No	1 (5.26)	10 (62.50)	8 (18.60)	3 (50.00)	22 (26.19)
Total	19 (100.00)	16 (100.00)	43 (100.00)	6 (100.00)	84 (100.00)
Significance	Fisher's exact test $p < 0.001$				

Note: *n* = 84 (two patients did not have an echo report). See supplementary materials Table I for CARPREG II risk tool echo parameters.

postpartum during the patients' hospitalisation. Overall, 6.7% of patients who had a cardiac intervention before pregnancy had adverse cardiac outcomes, compared to 42.9% of those without a previous intervention ($X^2 = 9.79$, $p = 0.002$). There was an association between prior cardiac interventions (*n* = 30) and GA at presentation ($X^2 = 7.85$, $p = 0.049$); thus, patients without prior cardiac interventions (*n* = 56) booked at a later gestation, with 70% (*n* = 39) booking for the first time in the late second to third trimester (> 24 weeks gestation).

The presence of CARPREG high-risk parameters on echocardiography correlated with cardiac class ($p < 0.001$) (Table III), with cardiomyopathy (*n* = 18, 94.74%), and valvular disease (*n* = 35, 81.40%), showing a higher prevalence of high-risk parameters.

Considering OCCU interventions, five patients with cardiomyopathy and six with valvular disease required ventilation in the OCCU, while for the congenital and "other" group, four patients needed intraoperative ventilation only ($p = 0.472$) (Table IV). Considering the high-risk parameters on echocardiography in these patients, five patients had a left ventricular ejection fraction (LVEF) of < 55%, three had mechanical valves, and one patient had an aortic valve area of < 1.5 cm^2; one had aortic dissection, and three patients had no high-risk parameters. Only patients with cardiomyopathy or valvular disease needed vasoactive support during their hospital stay, but there was inadequate statistical power to analyse between-group differences ($p = 0.164$) (Table IV).

Table IV: Cardiac group versus need for critical care interventions

	Cardiac group *n* (%) (*n* = 86)				
Need for ventilation (*n* = 24, 27.9%) (Fisher's exact test = 0.472)	**Cardiomyopathy**	**Congenital**	**Valvular**	**Other**	**Total**
Intraoperatively and OCCU	4 (21.05)	0 (0.00)	4 (9.30)	0 (0.00)	8 (9.30)
Intraoperative only	2 (10.53)	2 (11.11)	7 (16.28)	2 (33.33)	13 (15.12)
OCCU only	1 (5.26)	0 (0.00)	2 (4.65)	0 (0.00)	3 (3.49)
None	12 (63.16)	16 (88.89)	30 (69.77)	4 (66.67)	62 (72.09)
Total	19 (100.00)	18 (100.00)	43 (100.00)	6 (100.00)	86 (100.00)
Need for vasoactive support (*n* = 11, 12.8%) (Fisher's exact test = 0.164)					
Yes	4 (4.65)	0 (0.00)	7 (8.14)	0 (0.00)	11 (12.79)
No	15 (17.44)	18 (20.93)	36 (41.86)	6 (6.98)	75 (87.21)
Total	19 (100.00)	18 (100.00)	43 (100.00)	6 (100.00)	86 (100.00)

OCCU – obstetric critical care unit

Table V: Cardiac group versus CARPREG II risk score (*n* = 86) and mWHO risk score (*n* = 85)[2]

CARPREG II risk score (Fisher's exact test: *p* = 0.291)							
Cardiac group	***0***	***1***	***2***	***3***	***4***	***> 4***	***Total***
Cardiomyopathy (n = 19)	1 (5.26)	3 (15.79)	1 (5.26)	9 (47.37)	1 (5.26)	4 (21.05)	19 (100.00)
Congenital (n = 18)	5 (27.78)	3 (16.67)	2 (11.11)	5 (27.77)	1 (5.56)	2 (11.11)	18 (100.00)
Valvular (n = 43)	3 (6.98)	5 (11.63)	1 (2.33)	20 (46.51)	4 (9.30)	10 (23.26)	43 (100.00)
Other (n = 6)	0 (0.00)	0 (0.00)	1 (16.67)	3 (50.00)	2 (33.33)	0 (0.00)	6 (100.00)
Total	9 (10.47)	11 (12.79)	5 (5.81)	37 (43.02)	8 (9.30)	16 (18.60)	86 (100.00)
mWHO class (Fisher's exact test: *p* < 0.001)							
Cardiac group	***I***	***II***	***II-III***	***III***	***IV***		***Total***
Cardiomyopathy (n = 19)	0 (0.00)	0 (0.00)	9 (47.37)	0 (0.00)	10 (52.63)		19 (100.00)
Congenital (n = 18)	5 (27.78)	0 (0.00)	5 (27.78)	5 (27.78)	3 (16.67)		18 (100.00)
Valvular (n = 43)	0 (0.00)	0 (0.00)	16 (37.21)	13 (30.23)	14 (32.56)		43 (100.00)
Other (n = 5)	0 (0.00)	2 (40.00)	3 (60.00)	0 (0.00)	0 (0.00)		5 (100.00)
Total	5 (5.88)	2.(2.35)	32 (37.65)	18 (21.18)	28 (32.94)		85 (100.00)

Note: One patient could not be classified according to the mWHO risk scoring system because there is no specific group for ischaemic heart disease.
CARPREG – cardiac disease in pregnancy, mWHO – modified World Health Organization

The length of OCCU stay between the cardiac classes had a mean (SD) of 4.10 (4.78) days and a median of 3.00 days (IQR 2.00–5.00, $p = 0.37$). The outlier of 37 days was a patient referred at 26 weeks GA with H1N1 pneumonia and acute respiratory distress syndrome (ARDS) needing prolonged ventilation. She had severe MS, preeclampsia with HELLP syndrome, with a mWHO class of IV and a CARPREG II score > 4. She survived her CS at 27 weeks GA, but the baby suffered an early neonatal death.

There was a slight increase in the length of stay with late bookers, but it was not statistically significant. Since the length of stay is non-normally distributed, a robust regression model was used. For this purpose, quantile regression was used to model the length of stay on the baseline factors: maternal age, gravity, pulmonary oedema, preeclampsia, HR > 100/min, mWHO class, GA at presentation, HIV, and cardiac disease group. Median slopes and median differences were estimated with 95% CIs. Presenting with pulmonary oedema was the only significant baseline factor associated with length of stay. Those with this condition remained a median of 2.3 days longer (95% CI 0.2 to 4.4 days). For the covariates in the model, $p = 0.035$ was adjusted.

Regarding OCCU intervention and length of stay, the expectation that patients with intervention would have a longer stay was validated (ventilation $p = 0.027$, inotropic support $p < 0.001$). OCCU stays were increased when the patients had ventilation intraoperatively *and* in OCCU, with a median of seven-day stays. The median length of stay was six days for patients needing ventilation in the OCCU only, and three days for ventilation intraoperatively only or if no ventilation was needed. Likewise, the length of stay for patients needing vasoactive support in the OCCU versus those not needing it was a median of seven days versus three days ($p < 0.001$).

When assessing the disease group according to the risk-scoring systems, there was no significant association with the CARPREG II risk score, and there was insufficient power to detect an association ($p = 0.291$). However, there was a significant association with the mWHO class ($p < 0.001$). Cardiomyopathy and valvular groups have higher mWHO class levels (no I and II) (Table V).

There were 52 (60.5%) patients who had a CS. The primary indication for a CS was fetal distress, usually occurring after induction of labour (n = 19, 36.5%). Two-thirds (n = 34) of the CSs were emergencies, and one-third (n = 18) were elective. There was one perimortem CS during cardiac arrest; no anaesthesia was given. Two further patients needed evacuation of the uterus in theatre under general anaesthesia after vaginal delivery.

Anaesthesia provided for CS was epidural (46%), followed by general (37%), spinal (11%), and combined spinal-epidural anaesthesia (4%). Epidural analgesia was provided for labour in 12/22 (55%) normal vaginal deliveries and in 7/8 (88%) assisted deliveries. Nine of the 30 (30%) vaginal and assisted deliveries did not receive any anaesthesia care.

Regarding neonatal outcomes, 66 (75%) babies were alive needing no ICU care, 10 (11.4%) needed ICU care, and four (4.5%) were stillbirths, of which three (3.4%) were non-viable, and one (1.2%) was the baby of an unbooked mother at term born before arrival. Three (3.4%) suffered early neonatal deaths and three (3.4%) were intrauterine deaths. Medical termination of pregnancy was needed in two (2.3%) patients, one of whom had severe mitral valve disease and defaulted her treatment, and the other with DCMO with an LVEF of 20–25%. These two patients had a mWHO IV class, CARPREG II scores of 3 and > 4, respectively, and adverse cardiac outcomes. There were two twin pregnancies and a total of 88 neonates.

Discussion

Compared to published literature, our cohort of 86 patients signifies a high-volume unit.[3,16] In our study, the spectrum of cardiac disease showed that rheumatic valvular heart disease was the largest group (50%), with mitral valve disease (including mitral valve replacement, MS, and mitral regurgitation) predominating, followed by cardiomyopathy.

In India, a LMIC, rheumatic valvular disease was the most common pathology, comprising 69% of the cardiac spectrum.[6] These patterns relate to a lower socioeconomic status, possibly implicating a lack of preventative healthcare. In comparison to other SA studies, cardiomyopathy was the main pathology (55%) in a Free State study (2000), and mitral valve disease was the most common valvular pathology in an earlier study from the same region (1997).[17,18] In 2014, congenital heart disease was the most prevalent pathology at Groote Schuur Hospital, a neighbouring tertiary hospital in the Western Cape.[1] However, these studies described the outcomes of all patients managed in their respective cardiac clinics. Our study specifically reported on cardiac-obstetric patients admitted to the OCCU. These findings may suggest a change in disease patterns over the last 30 years in SA, but may also be due to differences in populations served within the public sector, referral systems, and preventative care efforts among tertiary hospitals in SA.

Van Hagen et al. studied rheumatic mitral valvular disease in pregnancy and concluded that interventions before pregnancy led to significantly fewer adverse cardiac events during pregnancy.[19] Our data are consistent with this finding, as there was an association between having had a cardiac intervention before pregnancy, predominantly for valvular and congenital diseases, and having fewer adverse outcomes. Only three (3.4%) patients had interventions during pregnancy, of whom two were late bookers. Most patients with no cardiac intervention before pregnancy were late bookers (70%), emphasising the need for intensive health education and advocacy among cardiac female patients regarding their diagnosis, treatment, and the specific risks during pregnancy.

The median length of OCCU stay was three days across the four major disease groups; however, critical care interventions (ventilation and vasoactive support) were associated with a longer OCCU stay. Presenting with pulmonary oedema was the only significant baseline factor associated with a prolonged stay. There is a paucity of data on the length of hospital stay associated with cardiac-obstetric patients, particularly critical care duration. The study in Bloemfontein, in the Free State province of SA, had a median length of 12 days of hospital stay with a maximum outlier of 82 days.[18] Our study reports a doubling of OCCU stay associated with ventilation and vasoactive support interventions.

A delay in seeking medical care and late gestation at first assessment are major contributing factors to cardiovascular morbidity and mortality.[2,10] The majority (62%) of study patients were late bookers, similar to two other SA studies.[1,20] This finding highlights the value of incorporating late pregnancy assessment into the CARPREG II risk score as a delivery-of-care predictor.[2] The CARPREG II risk tool may prove valuable to the risk assessment toolbox, emphasising key clinical parameters, such as functional status and delivery-of-care predictors (late pregnancy assessment); these issues require further investigation.[2]

The CS rate for TBH was 60.5% in this high-risk group. The high incidence of emergency CS and fetal compromise during induction of labour are concerning. There was no association with risk-scoring systems, cardiac outcomes, and the need for CS. By comparison, a study in Durban (SA) indicated 64% vaginal deliveries, with caesarean deliveries mostly done for obstetric indications.[20] Two other SA studies from tertiary units indicated a much lower CS rate of 30% in the cardiac-obstetric population.[1,18] Van Hagen et al. reported a 52% CS rate in an international registry of rheumatic mitral valve disease; however, it was noted that patients from resource-limited environments were mostly from Egypt and did not include sub-Saharan African countries.[19]

Epidural anaesthesia was the most frequently employed anaesthetic technique (47%) due to the gradual onset and less pronounced haemodynamic effects.[21,22] No anaesthetic care was provided for a large proportion (30% of non-operative deliveries). The explanation included late arrival at the institution and already in an advanced stage of labour, born before arrival, or delivery at a regional hospital and being referred postpartum; one patient also required a perimortem CS. These reasons again highlight the importance of early antenatal booking, patient

education, and system failures regarding timely referral and transport of patients.

Study limitations

As this is a retrospective study, we only assessed the in-hospital period and not after discharge. For example, only two deaths were recorded over the two years, both occurring during the patients' hospital stay, so our mortality rate is not comparable with other studies where follow-up extended to 42 days/six months postpartum, as per postpartum definitions.[1,17] Since this is a cohort study, we can only infer association, not causation. The study is subject to referral bias, as it was conducted in a tertiary setting. Lastly, some subgroups of diseases were too small for statistical analysis.

Conclusion

Patients admitted to the OCCU with cardiac disease in obstetrics had predominantly valvular heart disease, cardiomyopathy, and congenital heart disease. Although SA is classified as a UMIC, our spectrum of disease was more representative of a LMIC. Primary and secondary cardiac outcomes were more prevalent in valvular disease and cardiomyopathy. Patients with previous cardiac interventions had fewer adverse cardiac outcomes and booked earlier. Length of stay was higher when patients presented with pulmonary oedema and needed ventilation and vasoactive support. The CARPREG II risk-scoring tool may aid decision-making regarding early referral to obstetric tertiary and critical care services. The importance of planned pregnancy, early booking, and early referral to the correct level of care is emphasised for women of childbearing age with cardiac disease.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

Institutional and ethical approval was obtained from the Stellenbosch University Health Research Ethics Committee (ethics reference number S20/09/228) before the commencement of the study, and the declarations of the Helsinki principles were upheld. A waiver of consent was obtained as the data was anonymised and deidentified.

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Addendum

CARPREG II risk score[2]

Predictor	Points
Prior cardiac events or arrhythmias	3
Baseline NYHA III–IV or cyanosis	3
Mechanical valve	3
Systemic ventricular function LVEF < 55%	2
High-risk valve disease or left ventricular outflow tract obstruction (aortic valve area < 1.5 cm^2, subaortic gradient > 30, or moderate to severe mitral regurgitation, MS < 2.0 cm^2)	2
Pulmonary hypertension, RVSP > 49 mmHg	2
High-risk aortopathy	2
Coronary artery disease	2
No prior cardiac intervention	1
Late pregnancy assessment	1

Primary cardiac event risk: score = 1, 5% risk, score = 2, 10% risk, score = 3, 15% risk, score = 4, 22% risk, and 41% risk if score > 4.
LVEF – left ventricular ejection fraction, MS – mitral stenosis, NYHA – New York Heart Association Functional Classification, RVSP – right ventricular systolic pressure

mWHO risk score[23]

Conditions in which pregnancy risk is WHO I
Uncomplicated, small, or mild: • Pulmonary stenosis • Patent ductus arteriosus • Mitral valve prolapse
Successfully repaired simple lesions (atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage)
Atrial or ventricular ectopic beats, isolated
Conditions in which pregnancy risk is WHO II or III
WHO II (if otherwise well and uncomplicated)
Unrepaired atrial or ventricular septal defects
Repaired tetralogy of Fallot
Most arrhythmias
WHO II-III (depending on the individual)
Mild left ventricular impairment
Hypertrophic cardiomyopathy
Native or tissue valvular heart disease is not considered WHO I or IV
Marfan syndrome without aortic dilatation Aorta < 45 mm in aortic disease associated with bicuspid aortic valve
Repaired coarctation
WHO III
Mechanical valve
Systemic right ventricle
Fontan circulation
Cyanotic heart disease (unrepaired)
Other complex congenital heart disease
Aortic dilatation 40–45 mm in Marfan syndrome Aortic dilation 45–50 mm in aortic disease associated with bicuspid aortic valve

Conditions in which pregnancy risk is WHO IV (pregnancy contraindicated)
Pulmonary arterial hypertension of any cause
Severe systemic ventricular dysfunction (LVEF < 30%, NYHA III–IV)
Previous peripartum cardiomyopathy with any residual impairment of left ventricular function
Severe MS, severe symptomatic aortic stenosis
Marfan syndrome with aorta dilated > 45 mm Aortic dilatation > 50 mm in aortic disease associated with bicuspid aortic valve
Native severe coarctation

Risk class	Risk of pregnancy by medical condition
I	No detectable increased risk of maternal mortality, no or mild increase in morbidity.
II	Small increased risk of maternal mortality or moderate increase in morbidity.
III	Significantly increased risk of maternal mortality or severe morbidity. Expert counselling is required. If pregnancy is decided upon, intensive specialist cardiac and obstetric monitoring is needed throughout pregnancy, childbirth, and the puerperium.
IV	Extremely high risk of maternal mortality or severe morbidity; pregnancy contraindicated. If pregnancy occurs, termination should be discussed. If the pregnancy continues, care as for class III.

LVEF – left ventricular ejection fraction, MS – mitral stenosis, NYHA – New York Heart Association Functional Classification, WHO – World Health Organization