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Heart valve prostheses in pregnancy: Outcomes for women and their babies

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Abstract

Background: As the prognosis of women with prosthetic heart valves improves more of these individuals are contemplating and undertaking pregnancy. Accurate knowledge of perinatal outcomes is essential, assisting counselling and guiding care. The aim of this study was to assess outcomes in a contemporary population of women with heart valve prostheses undertaking pregnancy, and to compare outcomes for women with mechanical and bioprosthetic prostheses.

Method and results: Longitudinally-linked population health datasets containing birth and hospital admissions data were obtained for all women giving birth in New South Wales, Australia, 2000-2011. This included information identifying presence of maternal prosthetic heart valve. Cardiovascular and birth outcomes were evaluated. Among 1 144 156 pregnancies, 136 involved women with a heart valve prosthesis (1 in 10 000). No maternal mortality was seen among these women, although the relative risk for an adverse event was higher than the general population, including severe maternal morbidity (13.9% v. 1.4%, RR=9.96, 95% CI 6.32-15.7), major maternal cardiovascular event (4.4% v. 0.1%, RR 34.6, 95% CI 14.6-81.6), preterm birth (18.3% v. 6.6%, RR=2.77, 95% CI 1.88-4.07) and small-for-gestational-age infants (19.3% v. 9.5%, RR=2.12, 95% CI 1.47-3.06). There was a trend towards increased maternal and perinatal morbidity in women with a mechanical valve compared to bioprosthetic.

Conclusions: Pregnancies in women with a prosthetic heart valve demonstrate an increased risk of an adverse outcome, for both mothers and babies, compared with pregnancies in the absence of heart valve prostheses. In this contemporary population, the risk was lower than previously reported.

Key words: Pregnancy, heart valve prosthesis, cardiovascular diseases, perinatal mortality, infant

Introduction

With advances in surgical technique, prosthetic heart valve design and anticoagulation there has been an overall improvement in prognosis and quality of life of young women with a prosthetic heart valve [1-4]. There still remains a paucity of data in regards to the maternal, fetal and infant outcomes of the pregnancies of these women.

Normal pregnancy is a procoagulant state [5, 6] in which the body experiences an increased haemodynamic load [7-9]. Tolerance of these changes by women with pre-existing heart disease during pregnancy is known to vary [10]. With gradual improvements in risk stratification and understanding of what conditions and cardiac parameters drive high risk during pregnancy, the number of these women counselled explicitly against pregnancy is decreasing [10, 11]. Current knowledge of pregnancy outcomes for women with a previous heart valve prosthesis implantation remains limited. Previous research on the outcomes of pregnancies in these women reflects a population of women with largely older, more thrombogenic mechanical valves and focuses on anticoagulation regimen [12-17]. There is a need to examine pregnancy outcomes in a contemporary population, particularly given the increasing number of bioprosthetic valves implanted in women wishing to bear children, in accordance with international guidelines which advocate the consideration of this [11, 18, 19].

Improvement in care for chronic and congenital cardiac disease as well as the delayed age of childbearing is expected to contribute to an increase in the number of women with heart valve prostheses experiencing pregnancy. Routinely collected birth and hospital data represent an important resource for identifying women experiencing pregnancy with an existing heart valve prosthesis and provides data useful for exploring rare conditions, interventions and subsequent health outcomes. Contemporary knowledge is vital in assisting pre-pregnancy counselling and guiding care for women with heart valve prostheses and their offspring

during pregnancy and beyond. The aim of this study therefore was to assess the cardiovascular and birth outcomes of a contemporary population of women with a heart valve prosthesis undertaking pregnancy, and to compare outcomes for women with mechanical and bioprosthetic valves.

Methods

The study population included all women giving birth in New South Wales (NSW), Australia between 2000 and 2011. New South Wales (NSW) is Australia's most populous state with over 7 million residents (32% of the Australian population) and 95,000 births per annum [20].

Data were obtained from two routinely collected population datasets, the NSW Perinatal Data Collection (PDC) and NSW Admitted Patient Data Collection (APDC). The PDC, referred to as 'birth records', is a population-based surveillance system of all births (including all live births and stillbirths of at least 20 weeks gestation or 400 grams in weight). The APDC, referred to as 'hospital records', is an administrative database of all public and private hospital admissions. It includes 20 or more diagnoses and procedures for each hospital admission, coded according to the International Classification of Diseases Australian Modification (ICD10-AM) and the Australian Classification of Health Interventions. Record linkage of the PDC and APDC (including mothers' and infants' hospital admissions for the birth) and longitudinal linkage of hospitalisations up to 10 years prior to birth and 6 weeks postpartum) was undertaken by the NSW Centre for Health Record Linkage. As Australia does not have a unique registration number for citizens, the separate datasets were linked using probabilistic linkage methods and a best practice approach in preserving privacy [21, 22]. This involves a process of blocking and matching combinations of selected variables such as name, date of birth, address and hospital and assigning a probability weight to the match. The validity of the probabilistic record linkage is extremely high [23]. For this study, quality

assurance assessments reported false positive and negative rates of 0.3% and <0.5% respectively. Over 98% of birth records linked to a mother's hospital record. The study was approved by the NSW Population and Health Services Research Ethics Committee (Approval number: 2012/12/430).

Hospital records were used to identify women who had heart valve prosthesis implanted prior to the time of giving birth. Separate procedure codes for heart valve prosthesis implantation surgery by valve location and type of prosthesis exist. Women who had a heart valve prosthesis implanted prior to 2000 could be identified only by a ICD 10 AM diagnostic code indicating an extant prosthesis (Z95.2, Z95.3, T82.0) in the pregnancy/delivery hospital records, with no specification of valve type or location. After 2000, valve location and type of prosthesis was identifiable. Diagnoses of valvular disease and other maternal medical conditions, as well as cardiovascular outcomes, were also obtained from the hospital records; this information was not documented in the birth records. Valvular disease aetiology was obtained taken from any admission record with the relevant code, before or after valve replacement, or during pregnancy.

Maternal cardiovascular outcomes evaluated included stroke, myocardial infarction, heart failure, a new arrhythmia and endocarditis. Other vascular outcomes evaluated included new pulmonary embolism or other severe thromboembolic events. A composite outcome for any major cardiovascular event was used (stroke, myocardial infarction, heart failure, thromboembolic event and endocarditis) during pregnancy or up to 42 days postpartum. Severe maternal morbidity during the birth admission was measured using a validated composite outcome indicator that was developed specifically for use in routinely collected population health data [24].

The hospital and birth records provided maternal characteristics (age, country of birth, medical conditions), while birth records provided pregnancy characteristics (parity, induction of labour, mode of delivery, place of birth) and birth outcomes (gestational age, birthweight, perinatal death) for women who had a birth ≥20 weeks gestation. The birth record was also a supplemental source to identify women who suffered chronic hypertension, pregnancy hypertension (including gestational hypertension, preeclampsia and eclampsia) and diabetes (pre-existing and gestational). Only miscarriages (spontaneous abortion before 20 weeks gestation) that resulted in admission to hospital were identifiable from hospital records. Stillbirth was defined as fetal death of at least 20 weeks gestation or 400 grams birthweight. Neonatal death was defined as death of a live born infant during the first 28 days of life. Perinatal death included all stillbirths and neonatal deaths. Small for gestational age (SGA), a proxy for intrauterine growth restriction, was defined as <10th birthweight percentile for gestational age and infant sex [25]. Maternal length of stay and intensive care unit (ICU) admission during the birth hospitalisation (to discharge home) were obtained from the hospital data. Only pregnancy outcomes reliably reported in the population health data were included in the analyses [24, 26-28]. Information on medication use during pregnancy (i.e. use of oral anticoagulant or heparin) was not available on either dataset. No pregnancy or birth outcome information was missing for women with a heart valve prosthesis.

For the analysis of miscarriage and maternal characteristics, the study denominator was all pregnancies, including miscarriage. The analysis of delivery and birth outcomes was restricted to births ≥20 weeks gestation, for which outcomes such as SGA and perinatal death could be assessed. Admission summaries for women experiencing a miscarriage were also searched for diagnoses of major cardiovascular events, but none of the miscarriages in the study population were associated with such an event. The rates of birth outcomes for women with and without a prosthetic heart valve prosthesis (and mechanical versus bioprosthetic

valve type) were compared using contingency table analysis and by calculating rate ratios (RR) with 95% confidence intervals (CI). The comparisons of outcomes for women with mechanical prostheses versus bioprosthetic valves were similarly performed using contingency table analyses, as for almost all outcomes there were too few events to support a multivariable adjusted analysis.

Results

From 2000 to 2011, 87 women with heart valve prostheses experienced a total of 136 pregnancies. The prevalence of heart valve prostheses among the pregnant population was approximately 1 per 10,000 pregnancies (136/1 144 156). Baseline characteristics of the pregnancies with and without heart valve prostheses are shown in **Table 1**.

Thirty-five women had an admission record for their valve implantation procedure; this group experienced 58 pregnancies subsequent to this surgery. The average age at time of surgery for these women was 26.0 years (standard deviation ±6.2 years) and the mean interval between surgery and subsequent birth was 2.3 years (range 0.7 to 8.8 years). The remaining 52 women with a code identifying the presence of a heart valve prosthesis did not have an admission record for the valve insertion procedure, performed prior to 2000. The age of these 52 women as of 2000 ranged from 11 to 36 years, with a median age of 25 years. This group experienced 78 pregnancies during the study period. With the exception of four women (with six pregnancies) who had a diagnostic code indicating a xenograft valve, the valve prosthesis type and age at insertion in these women with pre-2000 valve prosthesis insertion was unknown. Combined with the four women identified as having a pre-2000 xenograft, the valve type (mechanical or bioprosthetic) was known for a total of 39 women experiencing 64 pregnancies. Valvular disease aetiology could be ascertained for 75 (55%) pregnancies, and of these 26 (19%) were attributed to rheumatic heart disease.

Of women with a known bioprosthetic valve, 46% experienced more than one pregnancy, as opposed to only 29% of those with a mechanical prosthesis. No pregnancies with prosthetic valves were complicated by pre-existing diabetes, but 13 were complicated by chronic hypertension.

Twenty-one women with a heart valve prosthesis were hospitalised with a miscarriage, 19 before 14 weeks gestation and two in the 14-19 gestational week category. A hospital admission with miscarriage was more frequent among women with valve prostheses than those without (15.4% versus 9.3%, RR=1.65, 95% CI 1.12-2.45), and among those with mechanical valves compared with bioprosthetic valves although this latter difference did not reach statistical significance (30% versus 14%, RR=2.20, 95% CI 0.81-5.98). For the 21 pregnancies ending in miscarriage with an associated hospital admission, no major cardiovascular events were identified, although one woman was diagnosed with a supraventricular tachycardia. Miscarriages not associated with a hospital admission were unable to be identified in women with or without prostheses.

Pregnancy outcomes for births ≥20 weeks gestation, with and without a prosthetic valve, are reported in **Table 2**. Compared with births where the mother did not have a prosthetic heart valve (n=1 144 020), those with valve prostheses (n=136) were more likely to have a hospital admission for arrhythmia (5.2% versus 0.3%, RR=16.0, 95% CI 7.35-35.0), have their pregnancy care in a tertiary centre (71.3% versus 44.7%, RR=1.60, 95% CI 1.42-1.79) and be admitted to intensive care during the birth admission (6.1% versus 0.8%, RR=7.34, 95% CI 3.58-15.1). One of the admissions for arrhythmia was an antenatal admission, the other five were at birth or postpartum. Of the arrhythmias documented, five were atrial fibrillation; one was non-specifically labelled as "tachycardia". Only five women with prosthetic valves suffered a major cardiovascular event. None of the women with a prosthetic heart valve were

diagnosed with endocarditis during pregnancy or the postpartum period. Women with a valve prosthesis were significantly more likely to have a preterm delivery (18.3% versus 6.6%, RR=2.77, 95% CI 1.88-4.07). These preterm deliveries were most commonly iatrogenic; by planned pre-labour caesarean section or induction of labour (12.2% versus 2.8%, RR=4.37, 95% CI 2.68-7.14). Overall, infants of mothers with a heart valve prosthesis had an increased rate of SGA (19.3% versus 9.5%, RR= 2.12, 95% CI 1.47-3.06).

Birth outcomes by mechanical versus bioprosthetic valve type, for the 52 births where valve type was known, are shown in **Table 3**. Numbers were small, with only incidence of caesarean section delivery and planned births (by labour induction or pre-labour caesarean) reaching statistical significance, which was higher in the group with a mechanical prosthesis. The point estimates of risk for preterm birth, postpartum haemorrhage, ICU admission and severe maternal morbidity were all higher for mechanical valve pregnancy. The rate of major CV events was roughly comparable between women with mechanical versus bioprosthetic valve, although a major cerebrovascular accident attribute to thrombosis was seen in one woman with a mechanical valve. The three events among women with bioprosthetic valves were all admissions due to congestive heart failure.

Discussion

From this large, contemporary, population-based study, pregnancies in women with a prosthetic heart valve demonstrate an increased incidence of adverse outcomes, for both mothers and babies, when compared with pregnancies in women without a prosthetic heart valve. Women with a prosthetic heart valve are at an increased risk of ICU admission, severe maternal morbidity or a major maternal cardiovascular event during pregnancy. Their babies are at an increased risk of preterm birth and small for gestational age. However, the frequency and rate ratios for these adverse outcomes were lower than previously reported in

population studies [29, 30] and a systematic review of women with mechanical heart valve prostheses only [17].

A previous systematic review of outcomes of women with heart valve prostheses undertaking pregnancy, focusing on impact of anticoagulation regimen, found maternal mortality complicated 2.9% (95% CI 1.9-4.2) of pregnancies in women with a mechanical heart valve prosthesis. A higher prevalence of other adverse events in these pregnancies was also reported, including major bleeding (2.5%, 95% CI 1.7-3.5) and thromboembolic events (3.9%-33.3%, dependent on anticoagulant regimen) [17]. While still demonstrating a higher incidence of perinatal mortality than among women without a heart valve prosthesis, complications in this NSW population were much fewer, with no maternal mortality seen. This likely reflects the contemporary population of valve recipients; with less of the more thrombogenic cage-and-ball style valves, accounting for 49.7% of the valves in women in the previous systematic review, as well as the presence of bioprosthetic valve recipients. In addition to the higher rate of thromboembolic events, the higher level of anticoagulation required for cage-and-ball valves is associated with an increased incidence of haemorrhagic events and fetal demise [17]. Based on the use of cage-and-ball valves over time in Australia [31, 32], and the maternal age of the study population, we estimate that no more than 3 of the 136 (2.2%) pregnancies in this study are likely to have occurred in the context of these valves.

The choice of valve prosthesis type in women of reproductive age remains at the discretion of the physician and woman. International guidelines recommend that bioprosthetic valves be considered in women wishing to undertake pregnancy in the future to avoid the complications associated with anticoagulation required for mechanical valves [11, 18, 19]. Current evidence suggests that there is no increase in deterioration of bioprosthetic valves during pregnancy [33-35] although there is a noted propensity for earlier valvular dysfunction with bioprosthetic

valves as opposed to mechanical valves, with implications for re-operation [36]. From the population data evaluated in this study there was a trend towards mechanical valve association with higher relative risk of ICU admission, cardiac events, PPH and stillbirth, when compared to bioprosthetic valves. Despite having 10 years of longitudinally linked birth data, a longer time frame may be needed to have sufficient number of birth outcomes by valve type to draw conclusions about relative birth outcomes.

Recently published studies which examine contemporary pregnancies in the setting of maternal mechanical or bioprosthetic heart valves include only small numbers of women with bioprosthetic heart valves, precluding subgroup analysis [30, 37, 38]. Larger studies focusing solely on pregnancies in those women with a bioprosthetic heart valve contain scant information on pregnancy and infant outcomes [33, 34, 39]. The cohort presented in this study, containing 38 pregnancies in which the woman was known to have a bioprosthetic heart valve, represents the largest published series examining maternal, fetal and infant outcomes in women with this type of prostheses with all pregnancies occurring in the contemporary setting (after 2000).

The propensity for development of congestive heart failure, seen in 8% of the women with a bioprosthetic valve and in previous studies [40-42], supports the need for a structured regimen of cardiac surveillance during pregnancy. There has been limited work advocating the role of serial B-type natriuretic peptide (BNP) measurements in predicting cardiovascular adverse events in pregnancy [43], not yet explored in the prosthesis setting. BNP has also been shown as a measure of valvular disease severity outside the pregnancy setting [44]. Further work in this area may allow women to be better informed about the risks of undertaking pregnancy and guide both obstetricians and cardiologists.

Infants born to women with a heart valve prosthesis in this study had an increased incidence

of preterm birth as well as SGA. Of the 21 preterm births, 14 were iatrogenic (12.2% versus 2.8%, RR 4.37, 95% CI 2.68-7.14). In a large, population-based Danish study prematurity was also the predominant adverse neonatal event, affecting 49% of live births. This was similarly iatrogenic, attributable to a high preterm caesarean section rate [30]. This method of delivery allows control of the anticoagulation regimen and decreases the risk of intracerebral haemorrhage associated with vaginal delivery of an anticoagulated fetus. SGA infants may also have been delivered electively pre-term due to concerns about intrauterine growth restriction or other fetal compromise, potentially contributing to the number of iatrogenic preterm births. The risk for extreme prematurity (gestational age 20-27 weeks), carrying the most significant morbidity, of infants born to mothers with a heart valve prosthesis in the NSW population was small (2.6%), although not insignificant.

The higher incidence of SGA infants seen has been noted in previous cohort studies examining populations of women with heart disease undertaking pregnancy [10, 45, 46] and specifically in pregnancy in the setting of heart valve prostheses [40, 42, 47]. A number of reasons have been proposed to account for this. Firstly, the potential inability of women with a degree of cardiac insufficiency to increase requirements sufficient for normal fetal growth, as postulated in studies where having a SGA infant was used to predict later maternal cardiovascular mortality in healthy women [48]. Or secondly, as a reflection of the poorer health status in general of women with chronic heart disease [46]. There has been limited work examining the longitudinal outcomes of infants born to a woman with a heart valve prosthesis, a potentially important area of further research given the increase in number of women with any heart disease undertaking pregnancy.

The strengths of this study include the size of the population evaluated, representing one of the largest reported series of pregnancies in contemporary heart valve recipients. This study

also provides the most comprehensive consideration of cardiac and perinatal outcomes in pregnancies subsequent to 2000 where a maternal bioprosthetic heart valve is present. Another strength is the known reliability of the reporting of the perinatal factors in the PDC, used in this study [26, 27]. While the validity of the identification of valve prostheses in routinely collected data has not been evaluated, other cardiac procedures (for example, angioplasty and coronary artery bypass grafting), the basis for billing, are reliably and accurately reported [49]. The high quality of the record linkage for the study highlights the value of record linkage in exploring rare conditions, interventions and subsequent health outcomes, with all women experiencing ongoing pregnancies in NSW and outcomes included.

While this study explores the pregnancy and birth outcomes for women with and without an existing prosthetic heart valve it is unable to answer whether women with a prosthetic heart valve are less likely or unable to experience pregnancy. Other limitations include a lack of detailed clinical information; data on medication use or the temporality of events during an admission was unavailable. Information on specific heart valve type (mechanical or bioprosthetic) for some women undergoing valve prosthesis implantation prior to 2000 was also unavailable, contributing to an incomplete profile for these pregnancies. There is also under-ascertainment of miscarriages and terminations of pregnancy in both women with heart valve prostheses and the wider population as this is only available if there is an associated hospital admission.

Conclusion

Pregnancies in women with a heart valve prosthesis, even in the contemporary setting, still demonstrate a higher incidence of adverse cardiovascular and pregnancy outcomes. The risk of these is relatively low and no maternal mortality was seen in this population. While this contemporary data supports that bioprosthetic valves are safer during pregnancy, larger

numbers of women are needed to confirm this as well as longer follow-up of valve related complications and childhood outcomes. Ongoing attention in this area is needed for the development of a structured, multidisciplinary regimen for obstetric and cardiac surveillance during pregnancy in women with a heart valve prosthesis.

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Disclosures

The authors report no conflicts of interest.

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Table 1. Pregnancy characteristics by maternal prosthetic heart valve status for all pregnancies*

Pregnancy characteristics	**Any prosthetic valve N=136 (87 women)**	**Mechanical valve N=20 (14 women)**	**Bioprosthetic valve N=44 (25 women)**	**Valve prosthesis type unknown N=72 (48 women)**	**No valve prosthesis N=1,144.020 (651,072 women)**
Maternal age (mean± standard deviation)	30.2 (5.6)	29.5 (7.4)	29.8 (4.5)	30.7 (5.7)	30.5 (5.7)
	n (%)	**n (%)**	**n (%)**	**n (%)**	**%**
Nulliparous	48 (35)	9 (45)	12 (27)	27 (38)	42.1
Maternal birth in Australia/NZ	101 (74)	13 (65)	35 (80)	53 (74)	68.4
Valve disease aetiology					
Rheumatic heart disease	26 (19)	6 (30)	8 (18)	12 (17)	0.06
Non-rheumatic	49 (36)	12 (60)	25 (57)	12 (17)	0.21
Not recorded	61 (45)	2 (11)	11 (25)	48 (67)	—
Valve prosthesis location					
Mitral	21† (15)	10 (50)	11† (25)	NA	—
Aortic	15† (11)	6 (30)	9† (20)	NA	—
Tricuspid or pulmonary	23 (17)	4 (20)	19 (42)	NA	—
Not recorded	78 (57)	0 (0)	6 (14)	72 (100)	—
Miscarriage admission	21 (15)	6 (30)	6 (14)	9 (13)	9.0

* Includes pregnancies ending in live birth, stillbirth or hospital admission for miscarriage
† One woman had both a mitral and aortic bioprosthesis at the time of pregnancy
NA not available, NZ New Zealand

Table 2. Pregnancy outcomes, by prosthetic heart valve status (all births ≥ 20 weeks)

Pregnancy outcome	Valve prosthesis N=115 n (%)	No valve prosthesis N=1,037,159 %	Rate ratio* RR (95% CI)
Pregnancy hypertension	17 (14.8)	9.5	1.67 (1.08-2.59)
Gestational diabetes	2 (1.7)	4.7	0.30 (0.08-1.17)
Induction of labour	32 (27.8)	25.2	1.10 (0.82-1.48)
Caesarean section			
Pre-labour	38 (33.0)	16.1	2.06 (1.59-2.67)
Intrapartum	14 (12.2)	11.9	1.02 (0.63-1.67)
Gestational age			
20-27 weeks	3 (2.6)	0.7	3.94 (1.29-12.0)
28-33 weeks	6 (5.2)	1.4	3.72 (1.71-8.11)
34-36 weeks	12 (10.4)	4.5	2.31 (1.35-3.95)
37-38 weeks	41 (35.7)	22.1	1.61 (1.26-2.06)
≥ 39 weeks	53 (46.1)	71.3	0.64 (0.53-0.78)
Planned preterm birth†	14 (12.2)	2.8	4.37 (2.68-7.14)
Perinatal death	2 (1.7)	0.9	1.96 (0.50-7.73)
SGA infant‡	22 (19.3)	9.5	2.12 (1.47-3.06)
Birth admission			
Severe maternal morbidity	16 (13.9)	1.4	9.96 (6.32-15.7)
Length of admission (days: median, IQR)	4 (3-7)	4 (2-5)	
ICU admission	7 (6.3)	0.8	7.34 (3.58-15.1)
Postpartum haemorrhage	17 (14.8)	7.1	2.09 (1.35-3.24)
Major maternal cardiovascular event to 42 days postpartum	5 (4.4)	0.1	34.6 (14.6-81.6)

* Rate ratio of each outcome among births where the mother had a prosthetic heart valve compared to those who did not have a prosthetic valve
† Induction of labour or pre-labour caesarean section at <37 weeks
‡ Denominator for SGA infant is all births >24 weeks, n=114

Table 3. Pregnancy outcomes by heart valve prosthesis type (mechanical or bioprosthetic)

Pregnancy outcome	**Mechanical valve N=14 n (%)**	**Bioprosthetic valve N=38 n (%)**	**RR (95% CI)***
Caesarean delivery	10 (71)	16 (42)	1.70 (1.03-2.79)
Preterm Birth (<37 weeks)	4 (29)	6 (16)	1.81 (0.60-5.47)
Planned birth†			
Any planned	13 (93)	24 (63)	1.47 (1.11-1.95)
Planned preterm birth	4 (27)	4 (11)	2.71 (0.78-9.41)
SGA infant	3 (21)	6 (16)	1.38 (0.39-4.70)
Perinatal death	0 (0)	1 (3)	not calculated
Postpartum haemorrhage	4 (36)	7 (18)	1.55 (0.53-4.50)
ICU admission	2 (14)	3 (8)	1.81 (0.34-9.72)
Severe maternal morbidity	4 (29)	6 (16)	1.81 (0.60-5.47)
Maternal major cardiovascular event	2 (14)	3 (8)	1.81 (0.34-9.72)

* Rate ratio of each outcome among births where the mother had a mechanical heart valve compared to those who had a bioprosthetic heart valve

† Induction of labour or pre-labour caesarean section