Characteristics and preventability of Obstetric ICU admissions in Far North Queensland

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Abstract

Background The rarity of maternal deaths in developed countries has increased interest in reviewing cases of severe maternal morbidity or maternal 'near miss'. Assessment and determining preventability among near misses is therefore important in improving the provision of maternity care. The aims of this study were to (i) describe the epidemiology of intensive care unit (ICU) admission in Far North Queensland (ii) determine the validity of the WHO near miss criteria in determining cases of severe maternal morbidity and (iii) determining preventability of severe maternal outcomes of pregnant and post-partum patients requiring admission to the ICU.

Methods Retrospective observational study included all patients pregnant or within 42 days of termination of pregnancy admitted to the Cairns Hospital ICU between 1st January 2013 and 31 December 2017. Cases were reviewed by a team of Obstetricians using the modified Geller model of preventability to determine reasons for admission to ICU and to determine whether the 'near miss' was preventable or not.

Results Sixty-nine out of 12081 (0.6%) women admitted for Obstetric care were transferred to the ICU with a total of 31 cases fulfilled WHO near miss criteria. The most common primary obstetric related diagnosis for ICU admission were hypertensive disease of pregnancy and obstetric haemorrhage. Indirect obstetric causes contributed to approximately 40% of ICU admissions. Among the 31 cases of WHO near miss, 10 cases were deemed preventable with the most common reason for preventability related to lack of recognition of high-risk clinical status.

Conclusion Maternal 'near miss' and rates of Obstetric admission to the ICU at Cairns Hospital are reassuringly low. An audit of near miss cases describing preventability is feasible and informs areas for improvement in the management of 'near miss' cases.

Background

Australia has one of the lowest maternal mortality rates in the world at 6.8 deaths/100,000 women¹. This equates to approximately 20 death per year nationally, indicating the rarity of maternal deaths, especially at the level of an individual institution. This rarity of maternal deaths in developed countries has resulted in an increased interest in reviewing cases of severe maternal morbidity or maternal 'near miss' to understand aetiological factors and improve the provision of maternity care within institutions²⁻⁴. Although there are differences in criteria identifying cases of severe obstetric morbidity internationally, admission to an Intensive Care Unit (ICU) is one of the most common end points in the management of cases of severe obstetric morbidity⁴⁻⁷.

Obstetric patients present a small percentage of critical care utilisation and conversely only a small percentage of obstetric cases require ICU admission⁸. However this population is an important and increasingly prevalent group as women give birth at later ages and develop co-morbidities prior to and during pregnancy⁹. Australian studies have also shown that a significant number of obstetric ICU admissions are undertaken for monitoring or precautionary measures rather than for intensive treatment to maintain organ function⁹⁻¹¹. The increased surveillance peri-partum in a critical care facility may be due to a lack of obstetric HDU units within Australia, preventing monitoring, and provision of medications outside an ICU setting. Australian studies into obstetric ICU admissions have been predominantly undertaken in large well resourced 'tertiary' hospital settings which differ in patient populations, geographic coverage and clinical resources to rural and regional areas in Australia.^{8, 9, 11, 12}.

Cases of severe maternal morbidity lie on a continuous spectrum of pathological deterioration leading to maternal death⁴. Although much has been described globally about the rate, aetiology and epidemiological characteristics of severe maternal morbidity, much less research has focused on preventability of cases of maternal 'near miss'. Assessment of preventability is required to determine areas for improvement and develop appropriate interventions to improve quality of obstetric care. Research indicates preventable severe maternal morbidity especially within the hospital setting contributes approximately a third of cases, with major factors being provider -related events such as delay/failure in diagnosis or recognition of high-risk status, inappropriate treatment and inadequate documentation^{7, 13, 14}.

This study was undertaken to understand the characteristics of Obstetrics ICU admission in a large regional Australian hospital, to assess the applicability of the WHO near miss criteria to severe maternal morbidity in our setting and to determine issues related to the preventability of maternal near miss.

Methods

Setting:

Cairns Hospital provides pregnancy and neonatal care for Far North Queensland and is the main referral centre for complex maternity care in the region, serving a population of 280,000¹⁵. There are 2500 deliveries per year and a staff of six fulltime obstetric specialists, supported by a neonatal special care unit (SCU) and a general ICU. High Dependency Unit (HDU) facilities are limited within the labour ward to the provision of eclampsia prophylaxis and monitoring of postpartum haemorrhage (PPH). The ICU includes ten ICU beds and six HDU beds with 7 fulltime specialist Intensivists providing 24 hour on-site medical care.

Any cases where delivery is anticipated before 29 weeks' gestation or cardiothoracic or neurosurgical management is required are transferred either to Townsville Hospital, the closest tertiary care facility 400km away or to the state capital Brisbane, 1700km to the South.

Inclusion Criteria and Definitions

This retrospective observational study included all patients who were pregnant or within 42 days of termination of pregnancy admitted to the Cairns Hospital ICU between 1st January 2008 and 31 December 2017. The cohort was identified by the departmental list of ICU admissions supplied by the Australian and New Zealand Intensive Care Society (ANZICS). The data was extracted from the ICU admission data base and in addition each patient's history was reviewed by two of the authors. The data was collected on customised forms and entered into a dedicated database. Research data included patient demographics, co-morbidities, diagnoses, pregnancy and delivery details, and intensive care severity of illness scores (Acute Physiology and Chronic Health Evaluation (APACHE II)) and interventions within ICU. The identified cases were further reviewed by the authors to determine those which fulfilled the WHO criteria for 'near miss'. The cases of maternal 'near miss' were classified by the same categories as for maternal death: direct (resulting from obstetric complications of the pregnant state) and indirect (resulting from pre-existing disease or disease developed and aggravated during pregnancy).

The cases fulfilling of WHO 'near miss' criteria were then further reviewed by a panel of three obstetricians and reasons for transfer and preventability using the validated categories published by Geller et al., were applied to the present audit¹⁶. These criteria primarily relate to the provision of care within or between medical facilities from the point of admission to discharge of the patient. Each of the ten broad criteria include subthemes that describe in detail the nature of the preventable event.

Result

During the five-year study period, 69 out of 12081 (0.6%) women admitted to the Cairns Hospital for antepartum, delivery or postpartum care were transferred to the adult ICU at some point in their hospital stay. These 69 patients constituted 2% of the 3642 admissions to the Cairns ICU during the study period. Seventy-one percent of admission were post-partum while the remainder were equally distributed between the three antepartum trimesters. One patient was admitted with the same diagnosis in two separate admissions. Twelve patients were transferred from peripheral hospitals to Cairns ICU. There was only one planned elective ICU admission postpartum for a woman with complicated rheumatic heart disease.

Thirty-one cases fulfilled WHO near miss criteria among the 69 cases admitted to ICU while information could not be attained for three cases.

The characteristics of patients and distribution of clinical interventions received in ICU are summarised in table 1. The most common intervention was invasive arterial pressure monitoring with an intra-arterial catheter. Significant intervention (need for >5U blood transfusion, prolonged intubation and ventilation and vasopressors) was required in 25 cases.

Table 1 – characteristics and distribution of interventions

Characteristics	Near Miss (n=31)	Non-Near Miss (n=35)	Total (n=66)
Age (years) (mean)	28	27	27.5
Parity (median)	2	0	1
Ethnicity			
- Indigenous	19 (29%)	17 (26%)	36 (55%)
- Non-Indigenous	11 (16%)	18 (28%)	29 (44%)
- Unknown	1 (1%)	0	1 (1%)
Mode of Birth			
- Early pregnancy loss	1 (1%)	5 (8%)	6 (9%)
- SVB	11 (16%)	9 (14%)	20 (30%)
- CS	19 (29%)	21 (32%)	40 (61%)
Gestation at Admission (weeks)			
- 0 - 12+6	3 (5%)	4 (6%)	7 (11%)
- 13 - 27+6	1 (1%)	5 (8%)	6 (9%)
- 28-42+0	2 (3%)	4 (6%)	6 (9%)
- Post-Partum	25 (38%)	22 (33%)	47 (71%)
Co-morbidities			
- Previous CS	2 (3%)	6 (9%)	8 (12%)
- GDM	2 (3%)	7 (11%)	9 (14%)
- Pre-existing DM	1 (1%)	0	1 (1%)
- Smoker	14 (21%)	14 (21%)	28 (42%)
BMI (kg/m ²) (mean)	30	27	28.5
Perinatal Outcome			
- Live Birth	29 (44%)	30 (45%)	59 (89%)
- Fetal Death	1 (1%)	0	1 (1%)
- Early Preg Loss	1 (1%)	5 (8%)	6 (9%)
Length of Stay (days) (mean)	46	38	42
Length of Stay >24 hours	22	22	44
Apache II score (mean)	13	9.5	11
Interventions			
- >5 Units PRBC	9 (14%)	0	9 (14%)
- Arterial Line	15 (23%)	9 (14%)	24 (36%)
- Central Line	12 (18%)	4 (6%)	16 (24%)
- Inotropic Support	9 (14%)	0	9 (14%)
- Mechanical Ventilation	10 (15%)	2 (3%)	12 (18%)
- Peri-partum Hysterectomy	2 (3%)	0	2 (3%)

The most common primary obstetric related diagnosis for ICU admission were hypertensive disease of pregnancy and obstetric haemorrhage. Indirect obstetric causes contributed to approximately 40% of ICU admissions with admission for sepsis the most common aetiology.

Table 2- Aetiology of ICU admissions

Aetiology	Near Miss n=31 (%)	Non-Near Miss n=35 (%)	Total n=66 (%)
Obstetric			
- Miscarriage/Ectopic	1 (3)	2 (6)	3 (4.5)
- Obstetric Haemorrhage	14 (45)	4 (11)	18 (27)
- Pre-eclampsia			
- Puerperal Sepsis	2 (6.5)	11 (31)	13 (20)
	1 (3)	4 (11)	5 (7.5)
Non-obstetric			
- Cardiac	3 (10)	1 (3)	4 (6)
- Respiratory	3 (10)	2 (6)	5 (7.5)
- Sepsis	4 (13)	6 (17)	10 (15)
- GIT	0 (0)	2 (6)	2 (3)
- Neurological	2 (6.5)	2 (6)	4 (6)
- Anaphylaxis	1 (3)	0 (0)	1 (1.5)
- Trauma	0 (0)	1 (3)	1 (1.5)

Among the 31 cases of WHO near miss, 10 cases were deemed preventable using Geller's criteria (Table 3). The most common reasons for preventability related to lack of recognition of high-risk status, documentation and transportation delays.

Table 3: Preventable or contributory factors in maternal 'near miss' cases

Case	Aetiology of near-miss	Preventability factors
Case 1	Post-partum haemorrhage (PPH) *	Delay in referral to obstetric provider at Cairns Hospital
Case 2	PPH*	Delay in recognition and referral of PPH; Transport delay as helicopter occupied; poor documentation of initial delivery time and when medical help sought
Case 3	Severe pre-eclampsia and acute renal failure	Prescription of medication exacerbating renal impairment
Case 4	Recurrent secondary PPH*	Delay of initial treatment of PPH; Delay in attaining uterine artery embolisation
Case 5	PPH *	Delay in recognition of PPH; skilled staff for surgical management not available; transport delay as helicopter occupied
Case 6	Ruptured ectopic pregnancy*	Delay in performance of laparotomy
Case 7	PPH*	Failure to treat initial PPH; delay in detection of ongoing PPH; failure in recognition of abnormal vitals; Delay in transfer to theatre and transfusion; transport delay as helicopter occupied; skilled staff for surgical management not available
Case 8	Status epilepticus	Inappropriate dose of medication provided
Case 9	PPH, bladder and ureteric injury	Inadvertent incision through bladder and upper segment of vagina at caesarean in prolonged labour
Case 10	PPH	Delayed identification of right uterine angle tear requiring return to theatre and laparotomy

*Transfer from peripheral hospital sites to Cairns Hospital

Discussion

This study is the first to review obstetric ICU admissions in a regional Australian context. The rate of obstetric admission to the ICU of 0.6% is consistent with other international and Australia studies indicating only a small number of obstetric admission ultimately require critical care intervention^{8-11, 17}. Similarly, despite the relatively higher level of medical co-morbidities and socioeconomic deprivation, the obstetric burden on ICU admissions in Far

North Queensland is modest with only 2 percent of admissions attributed to obstetric causes.

The small number of patients in our study limited statistical analysis of risk factors for ICU admission or maternal 'near miss'. However our data revealed a disproportionate inclusion of Indigenous women with 55% of ICU admission and 60% of maternal 'near miss' cases despite comprising roughly one-third of parturients. Although this relationship needs further assessment in a larger study population, the increased Indigenous proportion within our study is in keeping with the greater prevalence of medical comorbidities and socioeconomic deprivation in this sub-group. Our study did not show a trend towards increased morbidity with advancing maternal age or parity seen in other studies^{6, 11} but obesity remains a prominent factor with morbid obesity (BMI>35) present in 20% of the ICU admissions and 23% of the 'near miss' sub-group. Unsurprisingly and consistent with most ICU studies, most admission to ICU occurred in the postpartum period reflecting complications and the need for monitoring in the two most common aetiologies identified: post-partum haemorrhage (PPH) and pre-eclampsia. Delivery by caesarean section occurred in 60% of our cohort – significantly higher than the current unit rate of 32%. Although studies have indicated that caesarean sections, including previous caesarean delivery is associated with significant maternal morbidity^{18, 19}, review of our cases indicated that the higher rate was more reflective of the severity of the underlying conditions and the need for timely delivery. Among our cohort, only eight women had previous caesarean sections with no uterine ruptures or complications at surgery; however two of the 'near miss' PPHs resulted from tears at the time of caesarean section.

The most common primary obstetric related diagnosis for ICU admissions were hypertensive disease of pregnancy and obstetric haemorrhage consistent with Australian and international literature.^{7-11, 17} Of the 18 cases of obstetric hemorrhage, 75% met the WHO near miss criteria predominantly through the need for more than >5U blood transfusion, the need for peri-partum hysterectomy (2) or the need for vasopressors.

Indirect Obstetric causes contributed to approximately 40% of ICU admissions with admission for urosepsis and respiratory infections being the most common aetiologies.

Although admission to ICU may appear to be an epidemiologically useful marker of maternal morbidity, our data illustrates that over half of the patients admitted to the ICU were not near misses as classified by the WHO. Many of these cases required closer monitoring post-partum because they were deemed to be 'high' risk, rather than requiring any specific critical care intervention. This is particularly noted by the high percentage of women with pregnancy-associated hypertensive disease who had no specific ICU-related intervention apart from invasive arterial pressure monitoring and/or magnesium sulphate infusion. Additionally, one-third of ICU admission were less than 24 hours and along with the relatively low APACHE II scores, indicate the general trend towards admission for monitoring seen in the majority of the cohort. Our study indicated that most significant interventions were confined to 'near miss' cases which required comparatively higher rates of critical care support such as inotropic support, mechanical ventilation and blood transfusion. This lower threshold for admission to ICU for monitoring is seen in many well-resourced settings^{10, 20} and reassuringly reflects the capacity to provide care not available in lower income settings^{21, 22} but also the lack of development of obstetric high dependency units (HDUs). Studies in larger centres, particularly in the United States have suggested the possible benefits of obstetric HDUs²³ including minimising ICU resources, although the value and cost effectiveness of this approach, especially in geographically isolated population regions such as Far North Queensland remains to be validated.

Thirty-one among the 66 cases of ICU admission fulfilled WHO near miss criteria, most of them on the basis of interventional criteria such as transfusion of more than 5U of blood, peri partum hysterectomy, need for mechanical ventilation and the need for inotropic support. A smaller number were identified through biochemical based criteria such as high creatinine and platelet count < 50 and clinical based criteria such as respiratory rate (RR) >40 , shock or cardiac arrest. On their own, some of these latter criteria such as decreased platelets and increased RR per se may not necessarily indicate

severe maternal morbidity as most of these cases are managed conservatively without specific intervention. Additionally some cases such as those requiring vasoactive support (adrenaline and metaraminol) may be more reflective of practitioner preference or threshold and incorporation of other interventional criteria would provide more substantiation for fulfilling 'near miss' classification. In one instance, a woman received four units of blood and required urgent ligation of the inferior epigastric artery inadvertently damaged at time of drain insertion. Technically this was not a 'near miss' as the transfusion requirements were less than the 5 Units required but the requirement for urgent surgery should be an indicator that requires incorporation into any 'near miss' criterion. This study along with others undertaken in other centres in Australia^{3, 24, 25}, indicate the WHO near miss classification requires refinement within an Australian setting with the most useful criteria to be based around operative obstetric procedures, the need for blood transfusion and severe organ dysfunction requiring invasive haemodynamic and respiratory support. These interventional criteria are also more easily coded using International statistical classification of Disease (ICD) 10 and Australian Classification of Health Interventions (ACHI) codes and are more amenable to retrospective review. Aspects of the WHO near miss criteria such as biochemical parameters have utility particularly within an ICU setting and can be used to identify cases on a prospective basis but do not have appropriate ICD 10 codes which allow retrospective review. Clinical criteria are not as relevant in this setting as compared to resource-restricted settings where laboratory investigations are hard to attain or interventional criteria difficult to meet^{21, 22}. Further study is required validating the WHO near miss criteria in well-resourced settings such as Australia in particular correlating the criteria to current ICD 10 and ACHI codes to allow easier attainment of 'near miss' cases.

In reviewing the 31 cases of near miss, ten were viewed to have some aspect of provider/system related factor contributing the severe morbidity. This is in keeping with previous studies utilising Geller's preventability model which have shown that about one-third of cases have some level of provider or system related preventability^{7, 13, 14}. Most cases of provider related preventability relate to lack of diagnosis/recognition of

decompensation, followed by the lack of ability to undertake the appropriate procedures in a timely fashion. Of note, six of the ten cases of preventability highlighted were from rural or regional centres. It must be emphasised that many of these smaller peripheral units are run by competent Family Medicine or General Practitioner (GP) obstetricians who have a variable skill mix. Despite the small size of these units, many of them have blood products available and operating suite capacity for procedures when required. However, the lack of certain skills such as insertion of Bakri balloon, or identification of bleeding vaginal or cervical tears were limitations noted when cases were reviewed. Also the lack of recognition of decompensation or possibility of complications following childbirth is a major issue with the lack of experience of staff (midwives and doctors) in managing complex obstetric patients. Air transfer support is provided by the Royal Flying Doctors Service (RFDS) and Lifelight services but often only with one plane/helicopter operational at any one time – sometimes leading to delays in the transfer of patients. Road transport is possible from closer sites within 1.5 hours away but may be severely hampered by flooding in the ‘wet’ or Monsoon season.

This study was a retrospective study and may not have included all ‘near miss’ cases due to exclusion of non-ICU admissions which may contribute to severe maternal morbidity²⁶. However, among the most severe cases, the authors believe that ICU admission remains a very sensitive indicator of severe maternal morbidity. The small number of cases in our study limited statistical significance of different epidemiological factors and ICU admission - larger studies incorporating various hospitals in Northern Queensland over a longer period may help in determining the significance of these associations.

Preventability in the utilised Geller’s model was mainly focused on provider and system related preventability and not on patient factors. Smoking was present as a co-morbidity in nearly half of all ICU admissions and limited antenatal care attendance was a significant contributing factor in at least two of the ‘near miss’ cases. Assessment using a modified Geller’s tool incorporating patient ‘delays’ in future studies may help in identifying patient- associated factors for improvement. Additionally, our preventability review was an

internal review subject to bias - external review using trained multidisciplinary cohort of staff may provide a more objective assessment of preventability – this has been successfully undertaken in various local and national settings in New Zealand (NZ) but requires further validation in the Australian setting^{7, 13, 14}

Conclusion

This is the first study to characterise obstetric ICU patients in a regional Australian setting and overall maternal morbidity and obstetric ICU admission rates are reassuringly low. Obstetric haemorrhage and hypertensive disorders of pregnancy are the most common diagnoses for admission, although many cases are admitted for more intensive monitoring rather than for specific interventions. Maternal ‘near miss’ cases contributed approximately half of the ICU admissions with nearly one third of cases showing areas of preventability or improvement in the provision of care.

Abbreviations

APACHE II – Acute Physiology, Age, Chronic Health Evaluation

New Zealand (NZ)

ANZICS - Australian and New Zealand Intensive Care Society

BMI – Body Mass index

FNQ – Far North Queensland

GP – General Practitioner

Declarations

Ethics

The ethics approval to undertake this study (**HREC Reference number: HREC/18/QCH/57 – 1225 QA Project title:** Obstetric ICU Admission in FNQ) was provided by the Chair of the Far North Queensland Human Research Ethics Committee (EC00157). The study was approved as a quality improvement audit and the need for consent was waived by the above named ethics committee.

Consent to Publish

Provided by the Chair of the Far North Queensland Human Research Ethics Committee (EC00157). as part of the above ethics approval.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to clinical patient confidentiality but are available from the corresponding author on reasonable request.

Competing interests

Not applicable

Funding

Not applicable

Authors Contributions

SJ was involved in the design of the study, collection of data and descriptive analysis of the results and writing of the discussion. SJR was involved in the data collection and descriptive analysis of the data. CdeC and SJ were involved in the editing of the final manuscript. All authors have reviewed and approved this manuscript for publication.

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