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Epidemiology of obstetric critical care

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In the last 20 years, in developed countries, maternal mortality rates have fallen such that analysis of cases of severe maternal morbidity is necessary to provide sufficient numbers to give a clinically relevant assessment of the standard of maternal care. Different approaches to the audit of severe maternal morbidity exist, and include need for intensive care, organ system dysfunction and clinically defined morbidities. In both developed and developing countries, the dominant causes of severe morbidity are obstetric haemorrhage and hypertensive disorders. In some low-resource regions, obstructed labour and sepsis remain significant causes of severe maternal morbidity. The death to severe morbidity ratio may reflect the standard of maternal care. Audits of severe maternal morbidity should be complementary to maternal mortality reviews.

Key words: maternal mortality; severe maternal morbidity; obstetric intensive care; postpartum haemorrhage; eclampsia.

The 1997–1999 triennial report of the Confidential Enquiry into Maternal Deaths in the United Kingdom included, for the first time, a chapter on ‘near-miss and severe maternal morbidity’.¹ The rationale for including an audit of severe maternal morbidity is logical because maternal mortality rates have fallen so low in developed countries that it is difficult to garner sufficient numbers from which to draw clinical conclusions and formulate guidelines.^{2,3} For example, in a 4-year national review of maternal deaths in Canada from 1997 to 2000, there were 64 maternal deaths (44 direct and 20 indirect) in 1,054,828 live births.⁴ This does not mean that careful scrutiny of maternal deaths should not continue, but that a review of the more common causes of severe maternal morbidity is likely to provide a more clinically relevant measure of the standard of maternal care.^{5–9} This is particularly true at hospital or regional level where the number of maternal deaths should be extremely low. The Cochrane Review of Critical Incident Audit and Feedback to Improve Perinatal and Maternal Mortality

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and Morbidity sought randomized trials of critical incident audit and, not surprisingly, found that there were no suitable trials. They concluded that both perinatal and maternal death and morbidity reviews should continue.¹⁰

DEFINITIONS

Maternal obstetric morbidity may be defined as morbidity from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.¹¹ Mantel et al¹² defined severe maternal morbidity as 'a very ill pregnant or recently delivered woman who would have died had it not been but luck and good care was on her side'. They also use the term 'severe acute maternal morbidity'.¹²

The term 'near-miss' has been borrowed from the aviation industry to describe women that escape death despite suffering life-threatening illness or complications during pregnancy. While 'near-miss' is a catchy phrase, it is in some ways an inappropriate term. In the aviation industry, a 'near-miss' usually means just that; there is no collision and no casualties. However, with severe maternal complications in pregnancy, while the woman may survive, she can suffer long-term disability; for example, intracranial haemorrhage associated with severe pre-eclampsia/eclampsia. Thus, the term 'severe maternal morbidity' is now more commonly used.

PREVALENCE

The rates of severe maternal morbidity tend to parallel maternal death rates. Prevalence also depends on the definition of morbidity. In developed countries, morbidity rates range from 0.05 to 1.7%.^{13,14} In countries with low resources, prevalence ranges from 0.6 to 8.5%.^{15,16} Say et al.¹⁷, in a systematic review of 30 studies in 2004, found that within the different definitions of morbidity, the prevalence varied between 0.8% and 8.2% for disease-specific criteria, 0.4% and 1.1% for organ-system-based criteria, and 0.1% and 3% for studies using management-based criteria (e.g. need for emergency hysterectomy).

CLASSIFICATION

Many different classifications of severe maternal morbidity have arisen in the last 15 years and these will be considered below.

Intensive care

The need for maternal transfer to a medical or surgical intensive care unit (ICU) is an easily identified endpoint for audit. However, the availability and proximity of the ICU will influence the number of patients transferred. The lowest rates tend to be in free-standing maternity hospitals in which patients have to be transferred by ambulance to the ICU.^{13,18} There have been many such audits, and several of the most recent audits are outlined in [Table 1](#).^{3,13,15,18-37} Transfer rates range from 0.5 to 7.6 per 1000 deliveries. Even these rates may not necessarily be comparable as some of the hospitals have a significant proportion of their deliveries referred with high-risk complications from other regions. Others may include transfers to the central ICU that have delivered in other hospitals. Thus, although it is difficult to get accurate population-based studies, the overall requirement for intensive care is low.

Table 1. Obstetric admissions to medical/surgical intensive care units (ICUs).

Number of deliveries	Transfers to ICU	ICU admission rate per 1000 deliveries	Maternal deaths	Death to ICU transfer ratio	Country	Study period	Reference
61 435	126	2.1	1	1:126	Australia	1978–1989	Stephens ¹⁹
8000	32	4.0	4	1:8	USA	1985–1990	Kilpatrick and Matthay ²⁰
13 018	7	0.54	0	0:7	Ireland	1990–1991	Fitzpatrick et al. ¹³
15 323	38	2.5	7	1:5	USA	1983–1990	Monaco et al. ²¹
NS	58	—	4	1:15	Israel	1985–1993	Lewinsohn et al. ²²
21 983	23	1.0	2	1:115	England	1982–1986	Graham and Luxton ²³
25 000	65	2.6	0	0:65	Canada	1990–1994	Lapinsky et al. ²⁴
140 323	435	3.1	22	1:20	France	1991–1992	Bouvier-Colle et al. ²⁵
39 354	49	1.2	2	1:25	Hong Kong, China	1988–1995	Tang et al. ²⁶
6039	30	5.0	2	1:15	England	1991–1992	Bewley and Creighton ³
20 000	80	4.0	17	1:5	South Africa	1992	Platteau et al. ²⁷
76 119	55	0.7	2	1:28	Canada	1980–1993	Baskett and Sternadel ¹⁸
44 340	131	3.0	3	1:44	Canada	1991–1997	Mahutte et al. ²⁸
58 708	364	6.2	61	1:6	Morocco	1995–2002	Mjahed et al. ¹⁵
90 222	369	4.1	17	1:22	USA	1988–2000	Harris and Foley ²⁹
51 576	50	1.0	3	1:17	England	1988–1999	Murphy and Charlett ³⁰
49 349	233	4.7	8	1:29	USA	1991–1998	Gilbert et al. ³¹
159 896	83	0.52	3	1:28	Canada	1988–2002	Baskett and O'Connell ³²
32 967	33	1.0	NS	—	England	1993–2002	Selo-Ojeme et al. ³³
28 660	68*	1.4*	23	1:3	Brazil	1991–2000	Dias de Souza et al. ³⁴
18 581	142	7.6	7	1:20	Netherlands	1990–2001	Keizer et al. ³⁵
51 165	64	1.3	NS	—	Scotland	2001–2002	Brace et al. ³⁶
13 333	28	2.1	2	1:14	England	2003–2005	Germain and Piercy ³⁷

NS, not stated.

* Forty of 28660 deliveries, 28 transfers from other hospitals.

A number of common themes emerge from these reviews. In virtually all cases, the two main obstetric reasons for transfer are haemorrhage and hypertensive complications. Some idea of the severity of cases and the sophistication of medical services can be gleaned from the death to ICU transfer ratio, which ranged from 1:5 to 1:126. In the eight studies where it was reported the majority of ICU transfers were carried out post partum, the range was 58.1–91.0% and the average was 77.3%.^{15,18,20,21,24,29–31} This is not surprising as there is a practical reluctance to transfer mothers until the infant is delivered, with the potential need for management of labour and delivery and the requirements for neonatal care. One of the few things that unsettles the otherwise unflappable medical and nursing personnel of ICUs is a pregnant woman in whom labour may be imminent. In the eight reviews in which it was recorded the caesarean delivery rate was high, the range was 50–87.4% and the average was 64.6%.^{3,15,18,21,24,25,27,30} In most cases, caesarean section is performed because of the clinical condition causing the morbidity, rather than being its primary cause.

Labour ward intensive care

A small number of obstetric units, usually of large size and with a high level of critical care cases, have developed intensive care to a higher level on the labour ward than normal. These are variously known as 'obstetric intensive care', 'obstetric intermediate care' or 'obstetric high-dependency units'. These units can usually provide invasive cardiovascular monitoring and have medical and nursing personnel with additional training in critical care medicine, but stop short of being able to provide prolonged assisted ventilation. A summary of figures from three such studies are shown in Table 2; between 0.9% and 1.7% of obstetric patients end up having this type of critical care.^{14,38,39} In these units, 5–11% of mothers are ultimately transferred to a full medical/surgical ICU, representing 0.4–1.2 per 1000 of the total obstetric population. In all of these reports, the clinical indications for critical care were haemorrhage and hypertensive disorders. Obstetric units with these intensive care areas should reduce the need for maternal transfer to medical/surgical intensive care by

Table 2. Obstetric intermediate/intensive care units (ICUs).

Study population	Deliveries	Number to obstetric ICU	Obstetric ICU per 1000 deliveries	Maternal deaths	Death to obstetric ICU ratio	Number transferred to medical/surgical ICU No (%) per 1000 deliveries	Study period	Reference
Tertiary hospital, Tennessee, USA	22 651	200	8.8	7	1:29	9 (4.5) 0.4	1986–1989	Mabie and Sibai ³⁸
Tertiary hospital, Cape Town, South Africa	28 387	258	9.1	7	1:37	28 (10.9) 1.0	1992–1993	Johanson et al. ³⁹
Tertiary hospital, Texas, USA	28 376	483	17.0	1	1:483	34 (7.0) 1.2	1998–1999	Zeeman et al. ¹⁴

being able to manage cases of haemorrhage and severe pre-eclampsia/eclampsia to a higher level of critical care than is available on the standard labour ward. This may be particularly appropriate for those obstetric units that are freestanding, and therefore have to transport mothers for intensive care, and for large units that have many deliveries and act as a regional tertiary transfer unit. Local studies of maternal mortality and morbidity should identify such need.

Organ-system-based criteria

Audits of severe maternal morbidity have shown that approximately two-thirds of cases will be missed if the need for transfer to an ICU is the sole definition of severe morbidity. Thus, other classifications have developed, including those based on failure or severe dysfunction of any major organ system. The most commonly used classification in this category is that of Mantel et al.¹² This includes nine organ-system-based criteria: cardiac; vascular; immune; respiratory; renal; liver; metabolic; coagulation; and cerebral dysfunction. In addition, there are three management-based criteria: intensive care admission; emergency hysterectomy; and anaesthetic accidents. There are detailed clinical and laboratory criteria for each of these categories.¹² Seven recent studies using this classification system, or variation thereof, are shown in Table 3.^{7,12,36,40–43} Using this system, the morbidity per 1000 deliveries varied between 2.1 and 10.9. There was also a wide range in the maternal death to morbidity ratio from 1:0.8 to 1:49. This is the most sophisticated of the audit systems.

Clinically defined morbidities

Other audits of severe maternal morbidity have defined specific clinical entities that are clear and easily coded. Examples of these are shown in Table 4.^{16,32,44–46} All of

Table 3. Organ system dysfunction morbidity.

Study population	Deliveries	Number with morbidity	Morbidity per 1000 deliveries	Maternal deaths	Death to morbidity ratio	Study period	Reference
Pretoria, South Africa	13 429	147	10.9	30	1:5	1996–1997	Mantel et al. ¹²
Tertiary hospital, Dublin, Ireland	21 170	45	2.1	0	0:45	1999–2001	Sheridan and Byrne ⁴⁰
Pretoria, South Africa	13 854	121	8.7	26	1:5	2000	Vandecruys et al. ⁴¹
Two provinces in South Africa	NS	423	—	128	1:3.3	NS	Pattinson et al. ⁷
Scotland	51 165	196	3.8	4	1:49	2001–2002	Brace et al. ³⁶
Three hospitals in Dublin, Ireland	37 640	151	4.0	NS	—	2004–2005	Murad et al. ⁴²
Four regional hospitals in Uganda	55 803	229	4.1	269	1:0.8	1999–2000	Okong et al. ⁴³

NS, not stated.

Table 4. Clinically defined morbidity.

Study population	Defined morbidities	Deliveries	Number with morbidity	Morbidity per 1000 deliveries	Maternal deaths	Death to morbidity ratio	Study period	Reference
South-east Thames region, UK	Severe pre-eclampsia/eclampsia Severe haemorrhage (>1500 mL) HELLP syndrome Severe sepsis Uterine rupture	48 865	588	12.0	5	1:118	1997–1998	Waterstone et al. ⁴⁴
Eleven regions of nine European countries	Severe pre-eclampsia/eclampsia Severe haemorrhage (>1500 mL) Severe sepsis	182 734	1734	9.5	9	1:193	1995–1998	Zhang et al. ⁴⁵
Province of Nova Scotia, Canada	Eclampsia Blood transfusion >5 units Uterine rupture Emergency hysterectomy ICU admission	159 896	313	2.0	3	1:104	1988–2002	Baskett and O'Connell ³²
Nine hospitals in Benin, Cote d'Ivoire and Morocco	Severe pre-eclampsia/eclampsia Severe haemorrhage (>1500 mL) Blood transfusion Emergency hysterectomy Uterine rupture Severe anaemia (<6 g/dL)	33 478	2864	85.5	197	1:15	1999–2001	Filippi et al. ¹⁶
Seven regional hospitals in Lithuania	Severe pre-eclampsia/elcampsia HELLP syndrome Severe haemorrhage (>1500 mL) Severe sepsis Uterine rupture	13 399	106	7.9	1	1:106	2003–2004	Minkauskiene et al. ⁴⁶

HELLP, haemolysis/elevated liver enzymes/low platelets; ICU, intensive care unit.

these include severe haemorrhage and hypertensive disorders, along with other variables such as HELLP syndrome (haemolysis/elevated liver enzymes/low platelets), blood transfusion, severe sepsis, uterine rupture, emergency hysterectomy, ICU admission and severe anaemia (<6 g/dL). The advantage of this type of audit is that the clinical entities are so dramatic that inaccurate ascertainment is unlikely. The use of such clearly defined clinical morbidities may be appropriate for units with limited health record and coding facilities.

Single morbidity

Audit of single clinically morbid events can be undertaken to establish the incidence and risk factors for the individual condition in a local hospital, region or country.^{47–51} Other single entity audits may be undertaken to assess the standard of care. In a study by Andersgaard et al.⁵¹, the incidence of eclampsia in Scandinavia was confirmed to be low (0.5 per 1000). However, in an estimated 50% of cases, preventable factors were felt to be present, such as earlier intervention and guidelines for the appropriate use of magnesium sulphate prophylaxis. Two studies of postpartum haemorrhage in developing countries were undertaken to guide improved clinical care.^{52,53} One found that delayed referral and lack of active management of the third stage of labour was the cause of death and severe morbidity in most cases⁵², while in the second audit, it was felt that guidelines and education on the use of less-invasive surgical methods for the management of postpartum haemorrhage, such as intra-uterine balloon tamponade and uterine compression sutures, could be helpful in reducing hysterectomy rates.⁵³

SEVERE MORBIDITY AUDIT IN LOW-RESOURCE SETTINGS

A number of audits included in Tables 1–4 are from low-resource settings. In general, the main causes of morbidity are the same, haemorrhage and hypertensive disorders, but the death to morbidity ratio tends to be lower compared with developed countries. Two studies from Nigeria⁵⁴ and West Africa⁵⁵ showed that in addition to haemorrhage and hypertension, obstructed labour and sepsis remain significant risks to the mother. In the Nigerian study, there were 13 deaths out of 144 (9%) emergency admissions over a 6-month period. The main factors involved were delay in seeking care and delay in transfer for medical care. They advocated education of the patient population and the referral staff, along with use of the World Health Organization partogram to detect early signs of non-progressive labour.⁵⁴ In the audit of rural regions of West Africa, it was found that 3–9% of women experienced severe morbidity due to obstetric causes.⁵⁵ This review showed that re-organization of existing health services could diminish the risks and improve maternal outcome.

The death to morbidity ratio can be expressed as the number of deaths that result per morbidity, however that morbidity is defined. This ratio tends to be low in countries with lower resources, because those who have severe morbidity are more likely to die. The ratio will be higher when medical services are more sophisticated and may be falsely high if the definition of morbidity is broadened, such that less life-threatening morbidities are included. However, morbidity surveys are relevant in low-resource settings, many of which have improved their maternal mortality rates. Even with high mortality rates, severe morbidity surveys are complementary to mortality studies and can be helpful in delineating gaps in maternal care.

TRENDS

There is reason to believe that severe maternal morbidity may increase in developed countries.⁵⁶ This is likely because of the changing demographics of pregnant women in developed countries with increasing maternal age, increasing caesarean section rates and obesity.^{57,58} The most recent UK Confidential Enquiry into Maternal Deaths (2003–2005) implicated obesity in almost half of the deaths.⁵⁹ In addition, assisted reproductive technology has increased the number of multiple pregnancies, particularly triplets and higher. The greatest emphasis in this group has always been the increased perinatal mortality and morbidity, but there is evidence that severe maternal morbidity is also increased.^{56,60} In a study of severe morbidity in three regions of France, the odds ratio of women with multiple pregnancies requiring intensive care compared with singleton pregnancies was 2.5 [95% confidence interval (CI) 1.3–4.6].⁶⁰ Similarly, in one tertiary hospital in Canada, the relative risk of need for maternal intensive care for multiple pregnancies versus singleton pregnancies was 3.34 (95% CI 1.47–7.59; $P = 0.01$).⁵⁶

Another disturbing trend is the increased incidence of postpartum haemorrhage due to uterine atony shown in two recent studies.^{61,62} In the state of New South Wales in Australia, the incidence of postpartum haemorrhage rose significantly from 8.3% in 1994 to 10.7% in 2002 (a rise of 29%).⁶¹ In Canada, there was also a statistically significant increase from 4.1% in 1991 to 5.1% in 2004 (a rise of 24%).⁶² These audits, showing an unexpected and unexplained rise in postpartum haemorrhage rates, confirm the value of single morbidity audits carried out over time from routinely recorded data.

Another facet of severe maternal morbidity that has been largely ignored is the potential for long-term morbidity. Waterstone et al found that women with severe acute morbidity subsequently had poorer general health compared with controls, as measured by attendance at hospital clinics and emergency hospital admissions between 6 and 12 months post partum.⁶³

PREPAREDNESS FOR OBSTETRIC CRITICAL CARE

Obstetrics has always lent itself to audit and measurement. The main causes of maternal mortality and morbidity are known. National, regional and hospital audits will help delineate the main local threats, but in almost all studies of severe maternal morbidity, whether they be based on ICU admissions, organ system dysfunction or clinically defined morbidities, be they in developed or developing countries, the dominant obstetric causes are haemorrhage and severe pre-eclampsia/eclampsia. Similarly, the acute complications of labour and delivery involving uterine rupture, placenta praevia with or without accreta, and the need for emergency obstetric hysterectomy and blood transfusion are all predictable, if at most times occurring unpredictably. Thus, it should come as no surprise to personnel providing obstetric care that these conditions will occur, and therefore all units should plan for these inevitable complications. Such preparedness may involve drills⁶⁴, drug and management guidelines for severe pre-eclampsia/eclampsia⁶⁵, provision for massive blood transfusion⁶⁶, and availability of equipment for surgical management of postpartum haemorrhage.⁶⁷ It has been shown that local audits leading to recommendations will assist the implementation of appropriate equipment and guideline availability.⁶⁸ None of this is difficult to achieve and does not require expensive or technically advanced equipment in most

cases. It merely requires the will to audit local morbidity and practice, and to prepare for the complications that will inevitably occur. It must be acknowledged that certain local resources may be limited, but there is still much that can be achieved with organization and appropriate use of what resources are available.

There is little new under the sun and the words of James Blundell, the early 19th Century London obstetrician, remain as relevant today as they were more than 170 years ago⁶⁹:

'It is clear that when patients are in this condition, trembling upon the very brink of destruction, there is but little time for you to think what ought to be done, these are the moments in which it becomes your duty not to reflect, but to act. Think now, therefore, before the moment of difficulty arrives. Be ready with all the rules of practice, which those very dangerous cases require.'

Practice points

- in both developed and developing countries, the most common obstetric causes of severe maternal morbidity are haemorrhage and hypertensive disorders
- local audit of severe maternal morbidity can help pinpoint deficiencies in maternal care and guide development of appropriate resources and clinical services
- the death to severe morbidity ratio can be used as a guide to the standard of maternal care
- severe maternal morbidity audits should be regarded as complementary to maternal mortality reviews

Research agenda

- establish internationally agreed definitions of severe maternal morbidity
- design practical audit mechanisms of severe maternal morbidity for both high- and low-resource settings
- link maternal mortality and severe morbidity reviews
- long-term outcomes in women with severe maternal morbidity, including future reproductive performance

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