**1. Introduction**

Uterine rupture is a serious complication of labor, causing maternal and fetal morbidity and mortality around the globe, although much more frequently in low-income countries [1,2]. A WHO systematic review of maternal mortality and morbidity in 2005 showed large differences in the incidence of uterine rupture among countries. In high-income countries the incidence of uterine rupture was approximately 1% in women with an unscarred uterus, with less than 1 per 10,000 in women with a history of cesarean delivery [1].

A recent nationwide prospective cohort study in the Netherlands confirmed the rarity of uterine rupture in a high-income country setting. The overall incidence was 6.1 per 10,000 deliveries [3], most of which (86.7%) occurred in women with a history of cesarean delivery [4].

In low-income countries, however, uterine rupture was found to be a far more common problem, with overall rates ranging between 0.1% and 1% of all births [1]. The lack of differentiation of uterine rupture in women with and without a history of cesarean delivery is the most important shortcoming of the available data. In studies from Nigeria, Ghana, Ethiopia, and Bangladesh, about 75% of cases of uterine rupture occurred in women with an unscarred uterus, with obstructed labor being the most common cause [5-7]. Case fatality rates ranged between 1% and 13% and perinatal mortality between 74% and 92% [1]. Few studies have been done in rural areas of Sub-Saharan Africa, and most data are from urban centers, where the incidence of uterine rupture may be lower because services are more readily accessible [6,8–11].

In Thyolo district, Malawi, which is the setting of the present study, 23% of women deliver at the district hospital and 32% in public health centers. Adding women who deliver in the mission hospital and private clinics raises the total to 58.7% of deliveries in the district with inadequate hospital records (personal communication from district health manager). This reflects the situation of an overburdened health facility where documentation is not a priority [12]. The incidence of uterine rupture is unknown among those who do not reach a health facility [13].
The purpose of the present study was to improve obstetric care and to reduce the incidence of uterine rupture in Thyolo District Hospital. We performed an audit to identify the incidence of ruptured uterus and modifiable care-related factors [14].

2. Materials and methods

2.1. Setting

Thyolo District Hospital is located in southern Malawi, a low-income country classified by the UN as “least developed” [15]. The government hospital serves an area of approximately 600 000 inhabitants. Around 3500 deliveries are conducted in the facility every year, under supervision of midwives and clinical officers, a cadre of “non-physician clinicians” in Malawi. Due to a massive shortage of conventionally trained medical doctors, clinical officers perform the bulk of surgery in the hospital, including cesarean delivery [16]. In recent years, doctor vacancies been filled by one or two volunteer expatriate general physicians with experience in obstetrics [17]. They are available for consultation and major surgery. Services in Thyolo District Hospital are provided free of charge.

2.2. Study participants

This enquiry into uterine rupture is part of a larger 2-year study of severe acute maternal morbidity and maternal mortality (“4M-study”) in the hospital, which surveys all cases of mortality and severe morbidity, including uterine rupture. Other inclusion criteria to the 4M-study are adapted from similar international studies and include eclampsia, major hemorrhage (estimated blood loss >1 liter, or hemoglobin <6.0 g/dl, or blood transfusion >1 pint after acute blood loss) and severe infection (puerperal sepsis, bacterial meningitis, or other infection which is severe according to the clinician) [3,18–20].

We included all cases of uterine rupture that occurred in the 12-month period from 20 August 2007 to 20 August 2008. We defined uterine rupture as the occurrence of clinical symptoms (pain, fetal distress, acute loss of contractions, hemorrhage) or intrauterine fetal death that led to laparotomy, at which the diagnosis of uterine rupture was confirmed; or laparotomy for uterine rupture after vaginal birth [4]. To this definition we added rupture confirmed by autopsy or clinical symptoms with a high suspicion of rupture in case of death. Obstructed labor was defined as a delay in dilation of the cervix and descent of the fetal head during the active phase of labor with good uterine contractions, exceeding the commonly cited time limit of 12 hours in the active phase of labor [21,22].

2.3. Data collection

Data were collected as cases occurred; data were extracted from all available medical records on discharge, which included the prenatal register, partograph, and case file. After giving informed consent, the women or their guardians were asked to respond to a questionnaire. None of the women refused to give consent.

We recorded maternal characteristics (age, parity, level of completed education, employment, employment of partner, household income, HIV-serostatus); obstetric history (previous cesarean delivery); data on pregnancy and delivery (wanted pregnancy, planned pregnancy, prenatal visits, prenatal hemoglobin measurement, involvement of traditional birth attendant, involvement of health center, obstructed labor, operation type); maternal mortality; and perinatal mortality.

Data were entered in Microsoft Excel and analyzed with Epi Info version 3.4.3 (CDC, Atlanta, GA, USA).

2.4. Audit

Audit sessions with members of the hospital staff were performed once in every 2–3 weeks for 3 months from the start of the study period. In total, 5 audit sessions were held at every session, at least one member of the hospital management, one medical officer, one clinical officer, and one nurse/midwife or medical assistant were present. All staff members involved in maternity care were also invited to take part in the audit panel and usually many of them attended. Cases selected for audit were those that appeared to be of particular educational value to the primary investigator or any other hospital staff member.

The standards against which substandard care was measured were district health office protocols on prolonged labor, preoperative and postoperative management; transport protocols; and referral standards for health centers. These protocols generally follow WHO recommendations [23,24]. District health care was defined as substandard if at least half of the members of the audit panel independently assessed it as failing to meet these standards. The panel was requested to assess delays in referral, diagnosis, and treatment, as well as the quality of record keeping and to recommend improvements where substandard care was identified.

An extended audit and teaching session was held toward the end of the 3 months with internal staff and two obstetricians from teaching hospitals in Lilongwe, Malawi and Leiden, The Netherlands. A number of cases were again discussed, problems in service delivery were identified, and recommendations were made for improving care. A separate training session for midwives was also organized in the same week with the help of Médecins Sans Frontières/Belgium, Malawi mission, Thyolo project. Topics included the correct use of the partograph, and the identification of prolonged labor and risk factors for uterine rupture.

In addition, several health centers that had referred patients with uterine rupture were visited around the same time. Referred cases were discussed with health center staff and gaps in service delivery were identified, such as inadequate documentation, lack of active management of labor, and late recognition of risk factors. Traditional birth attendants throughout the district were given training as part of a national program on how to recognize danger signs of difficult delivery. Finally, the transport system between health centers and the district hospital was addressed by the District Health Management Team. Maternity cases were prioritized and an extra ambulance was made available for emergency duties during nights and weekends.

Each case was also examined for delays in referral, diagnosis, and treatment by the primary investigator. All cases were regarded to have occurred within our facility if the diagnosis of uterine rupture had not been made upon admission. Recommendations for improvement of care arising from the above audit processes were implemented after approval by the hospital management.

2.5. Ethical approval

Approval was obtained from the National Health Sciences Research Committee from the Ministry of Health, Malawi. The study was performed in accordance with the guidelines for operational research of the National Research Council and the Health Sciences Research Committee of the Ministry of Health of Malawi and with the Helsinki Declaration of 1975, as revised in 1983 [25,26].

3. Results

Table 1 shows the characteristics of all 35 cases of uterine rupture during the study period.

Median parity of the women was 3 (range, 0–7), mean age was 27.4 years (range, 18–40 years), and two-thirds were living below the
The poverty line of US $2 per day. The HIV-prevalence was 26%. Eleven of 29 pregnancies (38%) were unplanned and 8 (23%) were unwanted. During the first 3 months of study, 16 cases of ruptured uterus occurred in 833 deliveries, an incidence of 19.2 per 1000. Nine of the 16 ruptures occurred after the woman was admitted, 5 in women with an unscarred uterus and 4 in those with a history of cesarean delivery. The other ruptures occurred in unscarred uteri prior to hospital arrival. These numbers have been converted to incidence per 1000 deliveries in Fig. 1.

During the first 3 months of the study, 7 cases were audited by hospital staff, 4 of which ruptured in hospital. In all 4 cases, care at hospital level was assessed to be substandard according to the district health protocols. Of the 3 audited ruptures that occurred outside hospital, the assessors identified substandard hospital management of the complication in 2 cases. An example of one case is described below.

**Example**

A 25-year-old woman was admitted to Thyolo District Hospital. She was G4P3, 2 of her children were alive, 1 infant had died from malaria. The woman had dropped out from primary school, was HIV-negative and had previously been healthy. All 3 deliveries had been spontaneous. Her pregnancy was wanted and planned. She had attended the prenatal clinic twice during pregnancy; hemoglobin had been measured during the third trimester at 10.8 g/dL.

At 2:45 AM she was seen by a nurse/midwife in the labor ward. She reported that heavy labor pains had started at 6:00 PM the day before. She denied that she had visited a traditional birth attendant or a health center before arrival. The midwife examined her and found the cervix to be 9 cm dilated with moderate contractions. She artificially ruptured the membranes, the liquor was clear. Fetal heart tones were heard and were regular.

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At 6:00 AM, the midwife decided to start oxytocin (2.5 U in a pint of 5% glucose at an undocumented rate). By that time the cervix was fully dilated. At 6:45 AM the action line for multigravida on the partograph was crossed and she informed a clinical officer, who came to assess the patient at 9:15 AM, 2.5 hours later. By that time the woman had gone into shock and the clinician diagnosed uterine

![Fig. 1. Incidence and type of uterine rupture before and after audit in Thyolo District Hospital. Key: Red: ruptures that occurred after hospital admission in previously unscarred uteri; Orange: ruptures that occurred after hospital admission in previously scarred uteri; Yellow: ruptures that occurred before hospital admission in previously unscarred uteri. There were no ruptures in scarred uteri before hospital admission.](prgmea.com)
rupture. He consulted the medical officer on duty, who performed an emergency laparotomy. At 10:20 AM a fresh stillbirth weighing 4.4 kg was extracted, a large posterior rupture was found and subtotal hysterectomy was performed [27]. The woman was transfused 2 pints of whole blood preoperatively. Postoperatively she recovered well and was discharged on the ninth day post partum.

The case was discussed with an audit panel of hospital staff who unanimously agreed that rupture had been caused by major substandard care in hospital. Identified substandard care factors were: (1) poor assessment of potential risk factors by the midwife; (2) prolonged labor in a multipara; (2) incorrect indication for oxytocin after 12 hours of active labor; (3) midwife giving oxytocin without consulting a clinician; (4) inadequate case filing of labor management; (5) failure of the clinical officer to assess the woman in due time (2.5 hours); and (6) a delay in starting surgery of almost an hour.

A hospital protocol for augmentation of labor was developed. The midwife and clinician in question were briefed on the protocol, especially in association with other risk factors for uterine rupture (grand multiparity, previous cesarean delivery) [identified in 4 out of 4 cases that occurred during admission].

Poor case filing of delivery management, especially in case of augmented labor and other risk factors [in 3 out of 4 cases].

Delay in providing adequate treatment after a diagnosis of uterine rupture [in 2 out of 4 cases]. Decision-to-operation interval of all cases combined averaged 96 minutes.

Inadequate preoperative resuscitation (timely procurement of intravenous access with giving of intravenous fluids) [in 2 out of 4 cases].

Health center
1. Lack of documentation of management [identified in 3 out of 3 cases that occurred before admission in hospital]
2. Delay in decision to refer [in 2 out of 3 cases]

Transport
Delay of ambulance to arrive at health center, after health center staff had called for one [in 2 out of 3 cases]

Table 2 shows the main reasons for substandard care identified by hospital staff.

| Hospital | 1. Delay in recognizing prolonged labor because of poor follow-up of laboring women and delayed action to findings recorded in the partograph, especially in association with other risk factors for uterine rupture (grand multiparity, previous cesarean delivery) [identified in 4 out of 4 cases that occurred during admission]. |
| Health center | 1. Lack of documentation of management [identified in 3 out of 3 cases that occurred before admission in hospital] |
| Transport | Delay of ambulance to arrive at health center, after health center staff had called for one [in 2 out of 3 cases] |

only 2 uterine ruptures were audited, and the focus shifted to other complications. In general, compliance with the current hospital protocols improved.

Four maternal deaths and 29 perinatal deaths yielded a case fatality rate of 11.4% and a perinatal mortality rate of 829 per 1000 live births; 74% of ruptures occurred in unscarred uteri.

4. Discussion

The present study shows that audit of uterine ruptures is a useful tool to rapidly improve quality of care in a district hospital setting with a very high incidence of uterine rupture. The incidence of rupture reported in the first 3 months of the study has not often been reported in the literature [18–11.28]. However, it is unclear whether the incidence rate was a continuation of previous high trends in our facility because recording of uterine rupture before the advent of the “4M-study” was inadequate. Case fatality and perinatal mortality rates in our cohort were comparable with other studies in resource-poor settings [1,5]. The number of deliveries per month increased throughout the 1-year study period, probably because of simultaneous initiatives to encourage hospital deliveries.

According to hospital staff, uterine rupture has long been a neglected problem in Thyolo district, yet the reasons for its persistently high incidence have never been systematically described. The high prevalence of malnutrition in the district increases the baseline risk of complications of labor due to stunted growth and smaller pelvic size [29–31]. The high incidence in this study (31%) of ruptures in unwanted pregnancies, confirms the importance of promoting family planning in Thyolo [1].

Thaddeus and Maine [13] have classified delays leading to maternal mortality into 3 phases: delays at home before a decision is made to seek health care; delays in reaching the appropriate level of care; and delays in adequate management after arrival at the health facility. Using this approach, a number of factors can be identified that may lead to the high incidence of uterine rupture in Thyolo district.

Factors that may delay seeking treatment include a high female illiteracy rate (51.6%) [32], low social status [21,22,33], and cultural norms that make it more acceptable for women to deliver at home than in a health facility [33]. Delays in reaching the appropriate level of care may be due to travel costs and deficiencies in transport and referral systems [13,32,33], and factors delaying adequate management at the health facility are the shortage of qualified health staff [16,32], the performance of available staff [14], and the scarcity of blood for transfusion [34]. We hope that addressing these shortcomings and thus reducing delays in referral and obstetric management will also reduce delays in women in labor seeking health care [35].

One reason why audit may be effective is that health workers are stimulated to provide better care when they know that they are being monitored, independent of the educational value of audit sessions or the implemented policy changes [36]. This “watchdog function” may be especially important in settings where legal consequences for clinical mistakes are uncommon [14,37,38]. However, adverse effects of audit on staff motivation and cohesion have also been reported [14,39]. Although we did not specifically study the perceptions of audit by our staff, our experience certainly does not confirm these adverse effects. Audits in our hospital were well attended and much appreciated by all cadres of staff. The organizers of audit sessions tried to ensure open and constructive discussions, and to present audit as a learning experience, rather than as an opportunity to blame one another. Self-criticism from different cadres of staff was encouraged and respected.

Second, audit may enhance continuous professional development in cadres of staff that have had relatively little formal obstetric training owing to short training programs designed to rapidly increase numbers of health staff [38]. This is especially relevant in areas such as...
our district, with a shortage of human resources that requires more technically complicated work to be done by lower cadres of staff [16,38].

A third reason for the success of the Thyolo audit may be that audit sessions were also attended by district health managers. Their participation in the audit process made them aware of some of the challenges in the functioning of the district’s health system and allowed them to take appropriate action.

One important factor in substandard care, which has proven difficult to address, is the limited availability of blood. On average, women in our cohort received just over 1 pint of blood—inadequate to correct severe anemia. In one of the 4 maternal deaths, lack of blood for transfusion was a major contributing factor.

Audit is an inexpensive and simple intervention, requiring little technology [14,37,38], and is therefore an ideal method for health workers in resource-poor settings. By improving facility care through audit, health workers have the potential to help meet the targets set by Millennium Development Goals 4 (the reduction of child mortality) and 5 (the reduction of maternal mortality) [40]. A consequence of improved facility care could be more births attended by skilled health workers, as it becomes a more attractive option for pregnant women in the district [13,29,34,40].

The improvement of hospital care, however, should not be the only step in attempting to reduce the incidence of ruptured uterus in any given population. Community sensitization to influence health-seeking behavior of women and guardians is also necessary [40–42]. More specifically, health education provided to women and traditional birth attendants on danger signs during pregnancy and delivery, and encouraging women in the community to prepare for birth by making a birth plan, can be effective measures, which we seek to implement in the district [43].

It is the duty of the district management team to ensure access to safe delivery for all women in the area it serves [44]. Increased access to safe obstetric care is an essential element of the right to health [45], and any occurrence of uterine rupture due to obstructed labor, especially when rupture occurs within a health facility, is a violation of this right.

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Disclosure of interests

We declare that we have no conflict of interest.

Contribution to authorship

TvdA and JvR conceptualized the study. TvdA initiated it and was end-responsible for collection of the data, which were analyzed by TvdA and JL. BM participated in the planning of the study and provided managerial support during the implementation of audit results. BM and JvR were actively involved in the audit process. TvdA drafted the report, which was edited by JL and JvR. All authors have seen and approved the final version of this manuscript.

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