ORIGINAL ARTICLE

Operative Mortality in Resource-Limited Settings

The Experience of Médecins Sans Frontières in 13 Countries

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Objective: To determine operative mortality in surgical programs from resource-limited settings.

Design, Setting, and Participants: A retrospective cohort study of 17 surgical programs in 13 developing countries by 1 humanitarian organization, Médecins Sans Frontières, was performed between January 1, 2001, and December 31, 2008. Participants included patients undergoing surgical procedures.

Main Outcome Measure: Operative mortality. Determinants of mortality were modeled using logistic regression.

Results: Between 2001 and 2008, 19 643 procedures were performed on 18 653 patients. Among these, 8329 procedures (42%) were emergent; 7933 (40%) were for obstetric-related pathology procedures and 2767 (14%) were trauma related. Operative mortality was 0.2% (31 deaths) and was associated with programs in conflict settings (adjusted odds ratio [AOR] = 4.6; $P = .001$), procedures performed under emergency conditions (AOR = 20.1; $P = .004$), abdominal surgical procedures (AOR = 3.4; $P = .003$), hysterectomy (AOR = 12.3; $P = .001$), and American Society of Anesthesiologists classifications of 3 to 5 (AOR = 20.2; $P < .001$).

Conclusions: Surgical care can be provided safely in resource-limited settings with appropriate minimum standards and protocols. Studies on the burden of surgical disease in these populations are needed to improve service planning and delivery. Quality improvement programs are needed for the various stakeholders involved in surgical delivery in these settings.

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IT HAS BEEN ESTIMATED THAT OF the 230 million major surgical procedures performed worldwide annually, less than 4% are done in poor-income countries.[1] The fact that the latter bear the greatest burden of injury, violence, and maternal mortality indicates a substantial unmet need for surgical care, although few data exist about the burden of unmet surgical disease in the developing world.[2]

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Surgical practices in developed countries generally subscribe to quality control programs. To maintain accreditation, US hospitals that provide surgical services participate in the Surgical Care Improvement Project, which requires the use of certain protocols such as antibiotic prophylaxis and its timely discontinuation as well as the reporting of outcome measures through an automated database to reduce surgical complications.[3] Furthermore, some hospitals participate in the National Surgical Quality Improvement Program, a national database system that collects and reports risk-adjusted event data for surgical services and compares individual hospital mortality and morbidity against national norms. Participating hospitals must agree to keep a standardized database and meet minimum case standards.[4]

In resource-limited countries, these types of national programs to monitor and improve surgical quality improvement do not yet exist. There is a paucity of data on the safety of surgical programs in resource-limited settings, mostly due to a lack of resources to collect data or a centralized database to compare programs with one another. Long-term outcome data are particularly challenging to collect because patients do not always return once their surgical procedure is completed. In these settings, operative mortality can be a crude proxy for safe delivery of operative care.[5] Studies have reported intraoperative mortality as high as 5% to 10%.[6-8] Similarly, high

anesthesia-related mortality rates have been reported in a number of resource-limited settings, from 1 in 504 deaths in a central hospital in Malawi to 1 in 133 deaths in a teaching hospital in Togo.[9,10] As a consequence, the safety of international surgical care is being reexamined. In 2007, the World Health Organization launched the Safe Surgery Saves Lives project aimed at improving "the safety of surgical care around the world by ensuring adherence to proven standards of care in all countries."[11] The World Health Organization established a safety checklist to improve compliance with standards and decrease complications, and this has been shown to decrease mortality.[12]

Médecins Sans Frontières (MSF) is an international medical organization that provides surgical care in response to acute need from natural disasters, conflicts, or other humanitarian crises leading to elevated morbidity. In this article, we report operative mortality from 13 countries over 7 years and describe the main parameters that were found to be associated with operative mortality.

METHODS

CONTEXT

The study included 17 surgical programs from 13 countries that used a standardized electronic database between January 1, 2001, and December 31, 2008. All procedures were conducted, with permission of local health authorities, in government hospitals or structures built by MSF. In all sites where general surgical services were MSF supported, obstetric services were also supported. Frequently, MSF was the only provider of surgical care in the area. All care was provided free of charge.

All sites had electricity, clean water, sterilization units, operating rooms, postoperative surgical wards, postanesthesia care units, blood banks, anesthetics, analgesics, and antibiotics. Nearly every surgical program used nonsurgeons and nonanesthesiologists. Operations were performed by expatriate and local staff. Obstetric procedures were performed by general surgeons, obstetricians, and general doctors. General surgery and nonobstetric procedures were performed by general surgeons or general doctors with surgical skills. Obstetric fistula care was provided by surgeons with specific fistula training. Anesthesia was provided by nurse anesthetists and anesthesiologists. Most programs had only basic surgical equipment. For example, intramedullary nails were not available for femur fractures. There were no intensive care units. Only some programs had radiography or ultrasonographic diagnostic equipment; computed tomographic scanners and magnetic resonance imaging machines were not available. No site had pathology or histology services. All surgical programs followed perioperative protocols established by MSF such as preoperative antibiotics for procedures classified as clean contaminated, contaminated, or dirty. Some sites provided surgical and anesthesia training for national staff physicians and nurses.

DATA COLLECTION

Data were prospectively collected using a standardized database. Baseline characteristics on age, sex, and American Society of Anesthesiologists classification as well as data on surgical pathology, procedure type, and operative mortality were recorded in databases at the time of the procedure. For the analysis, programs were classified as conflict, postconflict, or specialty. Surgical pathology was grouped into the following categories: obstetric, infection, neoplasm, accidental injury, violent injury, and other. Procedures were classified as cesarean delivery, hysterectomy, minor surgery, orthopedic procedure, abdominal surgery, hernia or hydrocele repair, débridement, or other.

STATISTICAL ANALYSIS

Baseline characteristics were described using medians and interquartile ranges for continuous variables and counts and percentages for categorical data. Logistic regression was used to model determinants of mortality. Variables considered in the analysis included age, sex, surgical pathology, procedure type, emergency intervention, and American Society of Anesthesiologists score. Factors with $P < .10$ on univariate analysis were included in a multivariate model. All tests and confidence intervals were considered to be significant at $P \leq .05$. All analyses were performed using Stata version 10 statistical software (StataCorp LP, College Station, Texas).

ETHICS

Ethical approval was given by an independent ethics review board that screens research proposals by MSF.

RESULTS

Study site characteristics are listed in **Table 1** and patient and procedure characteristics are listed in **Table 2**. Between 2001 and 2008, 19 643 procedures were performed on 18 653 patients. Fifty-six percent of the patients were female; the median age was 28 years (interquartile range, 20-40 years). A total of 8329 procedures (42%) were emergent. Obstetric-related pathology was the indication for 7933 procedures (40%). A total of 2767 procedures (14%) were trauma related. Operative mortality was 0.2% (31 deaths). Programs in conflict settings (adjusted odds ratio [AOR] = 4.6; $P = .001$), procedures performed under emergency conditions (AOR = 20.1; $P = .004$), abdominal surgical procedures (AOR = 3.4; $P = .003$), hysterectomy (AOR = 12.3; $P = .001$), and American Society of Anesthesiologists classifications of 3 to 5 (AOR = 20.2; $P < .001$) were associated with higher operative mortality (**Table 3**). In the univariate model, the provision of training was found to reduce operative mortality (odds ratio = 0.03; $P = .001$), but this association was not sustained in multivariate analysis (AOR = 0.1; $P = .06$).

COMMENT

Operative mortality can be considered a crude proxy for safe delivery of operative care in settings where longer-term outcomes are unknown. This study demonstrated that surgical care can be performed in a variety of resource-limited settings with low operative mortality. Our programs spanned 17 sites in 13 countries where available resources and the training level of local staff varied. Eight of the 13 programs reported no deaths, and the highest mortality rate was 0.9%. Not surprisingly, programs in conflict settings were associated with higher operative mortality. Reducing operative mortality in these settings presents a particular challenge for humanitarian organizations, because of both the complexity of providing care in these settings and the sever-

Table 1. Surgical Programs From 2001 to 2008 by Médecins Sans Frontières[a]

Program	Country	Setting	Type	Years
Batangafo	Central African Republic	Postconflict	Emergency and elective	2006-2008
Kabo	Central African Republic	Postconflict	Emergency and elective	2006-2008
Bor	South Sudan	Conflict	Emergency and elective	2006-2008
Bangolo	Ivory Coast	Postconflict	Emergency and elective	2007-2008
Dargai	Pakistan	Conflict	Emergency and elective	2008
Lubutu	Democratic Republic of the Congo	Postconflict	Emergency and elective	2007-2008
Bongor	Chad	Postconflict	Emergency and elective	2001-2008
Iriba	Chad	Conflict	Emergency	2007-2008
Masisi	Democratic Republic of the Congo	Conflict	Emergency	2007-2008
Kirotshe	Democratic Republic of the Congo	Conflict	Emergency	2008
Gonaives	Haiti	Natural disaster	Emergency	2008
Guri-El	Somalia	Conflict	Emergency	2006-2008
Dakoro	Niger	Postconflict	Obstetric emergency	2007-2008
Kabezi	Burundi	Postconflict	Obstetric emergency	2008
Bo	Sierra Leone	Postconflict	Obstetric emergency	2007-2008
Tombouctou	Mali	Specialty	Obstetric fistula care	2008
Asmat	Indonesia	Specialty	Filariasis-related care	2008

[a] Belgian section.

Table 2. Patient and Procedure Characteristics for Surgical Programs by Médecins Sans Frontières From 2001 to 2008

Program	Interventions, No.	Female, No (%)[a]	Age, Median (IQR), y	No. (%)				
				Emergency[a]	Obstetrics	Trauma		Operative Mortality
						Nonviolent	Violent	
Kabezi	469	462 (100)	24 (20-30)	460 (98)	466 (99)	0	1 (0.2)	0
Batangafo	1837	781 (48)	29 (18-42)	716 (39)	323 (18)	150 (8)	73 (4)	0
Kabo	825	NA	NA	616 (75)	546 (66)	14 (2)	40 (5)	0
Bangolo	932	547 (59)	25 (18-32)	740 (80)	314 (34)	44 (5)	23 (3)	3 (0.3)
Kirotshe	94	71 (76)	25 (18-31)	36 (54)	36 (54)	9 (13)	4 (6)	0
Lubutu	2171	1020 (47)	32 (20-49)	750 (35)	368 (17)	190 (9)	14 (0.6)	5 (0.2)
Masisi	1291	904 (70)	24 (18-32)	1054 (82)	690 (53)	117 (9)	177 (14)	12 (0.9)
Gonaives	330	218 (66)	27 (17-38)	330 (100)	124 (38)	100 (30)	1 (0.3)	1 (0.3)
Asmat	36	0	40 (35-50)	0	0	0	0	0
Dakoro	250	196 (79)	24 (18-34)	208 (83)	179 (72)	1 (0.4)	2 (0.8)	0
Dargai	665	274 (41)	25 (15-38)	445 (67)	71 (11)	48 (7)	28 (4)	2 (0.3)
Bor	808	309 (38)	26 (14-37)	213 (26)	120 (15)	221 (27)	168 (21)	2 (0.2)
Bo	592	592 (100)	27 (21-34)	520 (88)	563 (95)	0	0	1 (0.2)
Guri-El	1367	NA	NA	NA	336 (25)	360 (26)	531 (39)	0
Bongor	7425	1997 (50)	35 (23-51)	1889 (25)	3511 (47)	159 (2)	137 (2)	1 (0.01)
Iriba	405	219 (54)	22 (16-30)	286 (71)	184 (45)	17 (4)	70 (18)	4 (1)
Tombouctou	146	146 (100)	30 (21-35)	16 (11)	146 (100)	0	0	0
Total	19 643	7736 (56)	28 (20-40)	8329 (42)	7933 (40)	1431 (7)	1336 (7)	31 (0.2)

Abbreviations: IQR, interquartile range; NA, not applicable.
[a] Data are available for 13 797 patients; Kabezi (n=462), Batanfalo (n=1627), Dargai (n=662), Dakaro (n=247), Bongor (n=3996), and Iriba (n=403).

ity of disease burden. Similar to other settings, we found that patients with higher American Society of Anesthesiologists classifications, those undergoing emergency procedures, or those undergoing complex procedures (abdominal surgery or hysterectomy) were also at increased risk for death.[13-16] Programs that provided surgery and anesthesia training to local doctors and nurses were not associated with higher operative mortality, although there was a trend toward a protective effect. In the United States, training programs are not associated with any difference in operative mortality.[17] Médecins Sans Frontières is committed to training a sustainable local surgical workforce, and we will continue to monitor operative mortality rates in these programs.

Most programs addressed emergency surgical needs, although some also provided elective care. In both conflict and postconflict settings, most emergencies were obstetric related. Undoubtedly, violent trauma increases in these settings, but in many contexts the prevention of maternal and neonatal mortality remains the most important reason for emergency

Table 3. Factors Associated With Operative Mortality in Surgical Programs by Médecins Sans Frontières

Factor	No. of Deaths per Total Procedures (%)	Unadjusted OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
Sex					
Male	15/6061 (0.2)	1 [Reference]			
Female	16/7736 (0.2)	0.8 (0.4-1.7)	.62		
Age, y					
<15	4/1794 (0.2)	1 [Reference]			
≥15	26/11 934 (0.2)	0.7 (0.2-1.9)	.47		
American Society of Anesthesiologists score					
1-2	13/19 018 (0.1)	1 [Reference]			
3-5	18/625 (3)	43.6 (21.1-88.9)	<.001	20.2 (8.9-45.7)	<.001
Surgical pathology					
Obstetric	10/7933 (0.1)	0.7 (0.3-1.5)	.36		
Infection	6/2357 (0.2)	1.8 (0.7-4.3)	.21		
Neoplasm	1/987 (0.1)	0.6 (0.1-4.6)	.65		
Other	6/5599 (0.1)	0.6 (0.2-1.5)	.26		
Accidental injury	1/1431 (0.1)	0.4 (0.6-3.1)	.40		
Violent injury	7/1336 (0.5)	4.0 (1.7-9.3)	.001	1.8 (0.7-4.8)	.26
Procedure					
Cesarean delivery	6/3233 (0.2)	1.2 (0.5-2.0)	.67		
Hysterectomy	3/678 (0.4)	3.0 (0.9-10.0)	.07	12.3 (2.9-52.1)	.001
Minor surgery	0/3266 (0.0)				
Orthopedic procedure	0/794 (0.0)				
Abdominal surgery	14/2035 (0.0)	7.2 (3.5-14.6)	<.001	3.4 (1.5-7.5)	.003
Hernia or hydrocele repair	0/3464 (0.0)				
Débridement	0/1198 (0.0)				
Other	8/4969 (0.2)	1.0 (0.5-2.3)	.95		
Procedure type					
Elective	1/11 314 (0.01)	1 [Reference]			
Emergency	30/8329 (0.4)	40.9 (5.6-299.9)	<.001	20.1 (2.7-150.7)	.004
Program setting					
Postconflict or stable	11/15 013 (0.1)	1 [Reference]			
Conflict	20/4630 (0.4)	5.9 (2.8-12.4)	<.001	4.6 (1.9-11.0)	.001
Program with training					
No	30/9912 (0.3)	1 [Reference]			
Yes	1/9731 (0.01)	0.03 (0.004-0.25)	.001	0.1 (0.02-1.1)	.06

Abbreviations: CI, confidence interval; OR, odds ratio.

surgery. Reducing maternal mortality is a Millennium Development Goal, and with already-fragile health care system collapse during war, the unmet need of obstetric care is large.

This study has certain limitations. Data were obtained from a database maintained for routine monitoring and evaluation. Our procedural coding system was not precise enough to analyze all procedures separately. It is possible that some deaths were not recorded, leading to an underestimation of operative mortality. However, because this was a prospective database, this type of misclassification can be expected to be low. Moreover, even if the death rate was a conservative estimate and actually twice as high, this would still be an acceptably low mortality compared with other reports in the literature.[6-8,16] In-depth case reviews are needed for all deaths to determine which deaths, if any, were preventable. In-hospital postoperative morbidity and mortality were not recorded. Long-term outcomes were especially challenging for surgical care in these settings. Patients lived far away, communication was poor, and follow-up was not routinely done. Better efforts to collect data on in-hospital complications as well as the tracing of certain high-risk patients (ie, following abdominal surgery or hysterectomy) are needed. Nevertheless, more than 19 000 procedures were performed with extremely low operative mortality, demonstrating that surgical care is feasible in resource-limited settings.

It is important to note that the classification of surgical activity does not accurately reflect the burden of surgical disease for our catchment populations. In certain settings, our mandate limited care to emergency surgical services, and even in settings where elective care was feasible, the range of procedures that could be provided was defined by the skills of the care providers and the limited surgical equipment. We believe that the unmet burden of surgical disease in these communities is large, and population-based surveys are urgently needed to better estimate this burden.

As a large provider of surgical care in developing countries, assuring quality is paramount for MSF. Our low operative mortality, even in a variety of emergencies, was partly the result of strict protocols for all essential aspects of surgical care. In most humanitarian contexts outcome data are difficult to collect, which means that structural and process indicators are even more important, as are minimum standards for essential items such as water, a blood bank, electricity, steriliza-

tion equipment, and a postanesthesia care unit. Finally, surgical care is often limited by the number of qualified surgeons and anesthesiologists, and many surgical programs are training other cadres of surgical providers. Strict protocols are therefore required to support the expansion of surgical services in this way. Médecins Sans Frontières has several quality assurance methods, including annual program audits, regular field visits by technical advisors, field reports by expatriate surgeons and anesthesiologists, a standardized data collection system, and ongoing national staff training.

A multitude of actors deliver surgical care in resource-limited settings, such as governmental providers, nongovernmental organizations, missionary groups, and other humanitarian groups. Services are provided in a variety of ways: surgical camps, independent hospitals, and collaborative efforts within government structures and health care systems. Amidst this diversity of settings, surgical standards and protocols vary or in some cases are nonexistent. Quality improvement programs are needed to regulate the enormous body of surgical providers in resource-limited settings. In this respect, the World Health Organization's Safe Surgery Saves Lives checklist is an important first step in a process of establishing global minimum standards in surgical care for humanitarian contexts. Operational research is needed to ensure such standardized approaches developed in relatively well-resourced settings are adapted to the complexities and constraints of humanitarian emergencies.

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Author Contributions: Drs Chu and Trelles had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Chu and Ford. *Acquisition of data:* Trelles. *Analysis and interpretation of data:* Trelles. *Drafting of the manuscript:* Chu and Ford. *Critical revision of the manuscript for important intellectual content:* Chu, Ford, and Trelles. *Administrative, technical, and material support:* Chu, Ford, and Trelles. *Study supervision:* Chu.
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