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FCA REFRESHER COURSE

Global surgical outcomes

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In this refresher course I will consider five points: i) the role of surgery in health equity, ii) the standards required to deliver safe surgery, iii) the current state of surgical delivery, iv) the resultant surgical outcomes in low-resource environments, and v) what we need to do to improve surgical outcomes in low-resource environments.

Keywords: surgery, complications, postoperative complications, mortality

The role of surgery in health equity

When one considers global health, which is well documented in the 'Our world in data' website (https://ourworldindata.org/health-meta), we see that life expectancy is increasing, child mortality and maternal mortality have been falling across all countries. The relative difference in health outcomes between countries is also falling, which means that society is moving towards greater health equality. The clarity of the progress made in health is well described in Steven Pinker's book 'Enlightenment now'.[1] However, we must not be fooled. Although all graphs are showing smaller gaps between income groups, the reality is that we are still a long way off health equality, if you consider, for example, that mortality following caesarean section in Africa is 50 times higher than that of high-income countries.[2]

The real issue about health, however, is not about equality, but rather about equity. Equality speaks to individuals or groups of people having access to the same opportunities. We could consider the increase in life expectancy and fall in mortality as increasing equality. However, this is not equity. Health equity recognises that each person has different circumstances and allocates the exact resources and opportunities needed to reach an equal outcome.[3] While equality is increasing, certainly equity is not.

Mortality and life expectancy numbers may demonstrate increasing equality, but I will demonstrate with surgical examples, how they hide the disparate inequity in health. This will demonstrate why there is a need for more and better surgical care in low- and middle-income countries.

The standards required to deliver safe surgery

The Lancet Commission for Global Surgery made recommendations for safe surgery to fulfil this need for surgery to ensure health equity.[4] These include: i) access to timely surgery, which is a facility that can conduct a caesarean section, laparotomy and an open fracture within two hours, ii) a specialist workforce of at least 20 specialists per 100 000 population, iii) the ability to conduct at least 5 000 surgical procedures per 100 000 population, and iv) protection against impoverishment and catastrophic expenditure through out-of-pocket expenditure.

The current state of surgical delivery

Based on data from large observational studies,[5-9] one can get a fairly good picture of surgical volume and the global surgery case-mix for countries across the human development index (Table I).[10]

Surgical volume

It is estimated that a functional healthcare system needs to be able to provide 5 000 surgical procedures in an operating room per 100 000 population.[4] We can estimate the volume of surgery conducted across human development quintiles (Table I). The number of surgical procedures performed is devastatingly low. Low-middle income countries only achieve a 1/5 of a minimum acceptable volume of surgery for the population, and in upper-middle income countries, 1/5 of the population do not receive the minimum acceptable volume of surgery.

Table I: Volume of surgery conducted according to human development index[10]

HDI	Cases per 100 000	Relative increase needed to reach 5 000 cases per 100 000
Low-income countries	356	14x
Low-middle income	1 096	5x
Upper-middle income	4 028	1.2x
High-income countries	11 150	

The volume of surgery in Africa leaves a lot to be desired.[10] Countries like Chad require 50x more surgery, and relatively affluent African countries such as Mauritius and Namibia need twice as many surgeries to reach 5 000 per 100 000 population.[10] Access to surgery is wholly inadequate across all income categories, with the exception of the generally over-serviced high-income countries.

Global surgery case-mix

The inadequate volume of surgery has implications for the surgical case-mix delivered (Table II). The four most striking observations are the following. As the human development index decreases, the proportion of elective surgery falls, the proportion of caesarean sections increases, the proportion of cancer surgeries decreases, and the proportion of 'other' surgeries decreases.

If surgery is not readily accessible, the proportion of emergency surgeries increases. Basically, a large proportion of surgical pathologies will convert from elective procedures to emergency procedures as the surgical pathology progresses or complicates without timely surgery. The result is an increase in morbidity and mortality. The proportional increase in obstetric procedures as the human development index falls is dramatic, where in Africa, one in three operations is a caesarean section.[9] Cancer surgeries, and 'other' surgeries (which are essentially specialised surgeries) are literally 'removed' in low-resource environments.

The proportional increases in surgeries required

To understand the surgical volume and case-mix requirements for low- and middle-income countries, it is instructive to use the United Kingdom as a benchmark for a high-income country, as it provides just over 5 000 surgical procedures per 100 000 population per annum, or just over the recommended minimum surgical delivery.[10] If we assume the proportions of surgeries delivered in the UK are acceptable, we can compare the surgical volumes provided for cancer, benign surgical conditions, obstetrics and an 'other' category of surgical subspecialities which individually contribute less than 5% of all surgeries performed. (The demand for cancer surgery has been corrected by the proportion of deaths attributable to cancer according to the WHO 2016 data,[11] as there is a lower proportion of cancers in low- and middle-income countries, due to the younger patient profile.[12] In high-income countries, cancer attributable deaths are approximately 27%, while in low-income countries [LIC] it is 7.1%, low-middle income countries [LMIC] it is 9.3% and upper-middle income countries [UMIC] it is 20.7%.[11]) This 'other' category is important, as it includes the subspecialities of breast surgery, cardiac surgery, neurosurgery, thoracic surgery and vascular surgery.[10] The dramatically low volume of surgeries performed across the board is clear to see in Table III, and the proportional increase needed in surgical volume per category is also shown.

In low-resource environments, subspeciality surgeries and cancer surgeries could be considered 'neglected surgeries'.

Table II: Surgical case-mix by Human Development Index Quintile[10]

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Emergency surgery	Proportion of total surgical volume	25.6%	21.6%	32.3%	58.5%	56.9%
Elective surgery	Proportion of total surgical volume	74.4%	78.4%	67.7%	41.5%	43.1%
Obstetrics and gynaecology	Proportion of elective surgery	11.8%	13.1%	12.7%	26.4%	36.7%
Obstetrics	Proportion of overall obstetrics and gynaecology	20.0%	40.0%	40.0%	45.0%	47.5%
Gynaecology	Proportion of overall obstetrics and gynaecology	80.0%	60.0%	60.0%	55.0%	52.5%
	Proportion performed for cancer	25.0%	25.0%	20.0%	30.0%	25.0%
	Proportion performed for benign pathology	75.0%	75.0%	80.0%	70.0%	75.0%
Colorectal surgery	As a proportion of elective surgery	7.1%	7.3%	5.4%	6.9%	7.4%
	Proportion performed for cancer	65.0%	60.0%	35.0%	30.0%	20.0%
	Proportion performed for benign pathology	35.0%	40.0%	65.0%	70.0%	80.0%
Head and neck	Proportion of elective surgery	13.0%	12.9%	19.1%	6.6%	9.1%
	Proportion performed for cancer	17.5%	20.0%	15.0%	10.0%	12.5%
	Proportion performed for benign pathology	82.5%	80.0%	85.0%	90.0%	87.5%
Plastic surgery	Proportion of elective surgery	4.5%	5.3%	1.4%	6.3%	6.8%
	Proportion performed for cancer	40.0%	40.0%	20.0%	20.0%	17.5%
	Proportion performed for benign pathology	60.0%	60.0%	80.0%	80.0%	82.5%
Upper gastrointestinal and hepatobiliary	Proportion of elective surgery	8.0%	11.9%	12.7%	5.9%	3.9%
	Proportion performed for cancer	30.0%	40.0%	30.0%	20.0%	15.0%
	Proportion performed for benign pathology	70.0%	60.0%	70.0%	80.0%	85.0%
Urology	Proportion of elective surgery	11.9%	10.7%	10.1%	8.9%	12.9%
	Proportion performed for cancer	33.8%	30.0%	25.0%	10.0%	10.0%
	Proportion performed for benign pathology	66.3%	70.0%	75.0%	90.0%	90.0%
Orthopaedics	Proportion of elective surgery	23.1%	17.8%	16.5%	18.4%	12.8%
Other surgery	Proportion of elective surgery	20.7%	21.0%	22.0%	20.5%	10.4%

Table III: Volume of surgery conducted per 100 000 population by surgical category

HDI	Cancer	Increase needed	Benign	Increase needed	Obstetrics	Increase needed*	Other	Increase needed
Low-income country	22	10x	122	24x	37		18	58x
Low-middle income	71	4x	356	8x	56		126	8x
Upper-middle income	519	1.2x	2 150	1.4x	182		811	1.3x
United Kingdom	860		2 975		120		1 045	
United Kingdom proportions	17.2%		59.5%		2.4%		20.9%	

*Caesarean sections are proportionally over-represented, but the volume is numerically insufficient

Table IV: Mortality and global surgical outcomes

Cohort	Region	Date	Outcome definition	Outcome
Adults				
VISION (all surgeries)[16]	Global	2007–11	30 day mortality	1.9%, 95% CI 1.7–2.1%
ISOS (elective surgery)[8]	Global	2014	In-hospital mortality	0.46%, 95% CI 0.4–0.52
ASOS (elective surgery)[9]	Africa	2016	In-hospital mortality	1.1%, 95% CI 0.8–1.4%
ASOS (all surgeries)[9]	Africa	2016	In-hospital mortality	2.1%, 95% CI 1.9–2.4%
Paediatrics				
APRICOT[17]	Europe	2014–15	30 day in-hospital mortality	0.1%, 95% CI 0.07–0.14%
SAPSOS[14]	South Africa	2017	In-hospital mortality	1.1%, 95% CI 0.6–1.5%
Caesarean section				
NSQIP[18]	United States of America	2006–12	In-hospital mortality	0.01%, 95% CI 0.01–0.02%
ASOS[2]	Africa	2016	In-hospital mortality	0.5%, 95% CI 0.3–0.8%

What we have not considered are children. Although the global surgical case-mix of children is not documented, it is unlikely that this picture of unmet need is any different. Indeed, the unmet surgical need may be worse in the paediatric population due to the higher proportion of young people constituting country demographics in low- and middle-income countries. In the sub-Saharan African countries, children under the age of 15 years accounted for 42% of the population.[13] A large prospective observational study of surgery in children in South Africa estimated that in South Africa, we are only meeting between one-third and one-fifth of the predicted surgical need in children.[14] This is an important observation, as South Africa is an upper-middle income country, and these countries achieve approximately 80% of the surgical volume needed. The paediatric surgical volume is between 20% and 33% of the need. It is likely to be far worse in low-middle and low-income countries. Paediatric surgery is also a neglected subspeciality surgery. It requires additional skills, and it is proportionally under-represented.

Implications of 'neglected surgeries'

I would suggest that about 30% of global health requirements or population health has a surgical component. There are a number of approaches to reach this conclusion. A simple approach is the frequency of operations per admission to hospital according to global burden of disease categories.[4,15] Approximately one-third of all hospital admissions are for surgery. The real numbers are 28.6% of all admissions are for surgery; communicable diseases, maternal, neonatal and nutritional disorders at 23.9%; non-communicable diseases at 33.9%; and injuries at 34.6%.[15] The categories that exceed one-third of all admissions include maternal disorders, transport injuries, unintentional injuries excluding transport, digestive tract, neoplasms, and musculoskeletal.[15]

In Africa, the most common indication for surgery is non-communicable disease (42%), then caesarean section (27%), trauma (18%) and acute infection (13%).[9]

Surgical outcomes in low-resource environments

There are a number of large prospective observational studies which document surgical outcomes globally. These allow interpretation of surgical outcomes in lower-resourced environments (Table IV). Mortality is twice as likely in Africa following adult surgery,[9] 50 times higher following caesarean section,[2] and 10 times as likely following paediatric surgery[14] when compared to high-income countries.

Complications leading to mortality

Complications following surgery are lower in Africa following elective surgery; ASOS (12.1%, 95% CI 11.1–13.1),[9] compared to ISOS (16.8%, 95% CI 16.4–17.1),[8] which is significantly less in Africa ($p < 0.0001$). This is probably secondary to the lower burden of comorbidities of the African surgical cohort.

In the VISION cohort, the most common complications were major bleeding (15.6%), myocardial injury after non-cardiac surgery (MINS) (13.0%), infection without sepsis (5.4%), and sepsis (4.5%).[19] Eight complications were independently associated with mortality: major bleeding, MINS, sepsis, acute

kidney injury with dialysis, stroke, venous thromboembolism, congestive heart failure, and new clinically important atrial fibrillation. The three complications with the largest attributable fractions (i.e. potential proportion of deaths attributable to these complications) were major bleeding ([15.6%]; adjusted hazard ratio [aHR] 2.6; 95% CI 2.2–3.1; attributable fraction [AF] 17.0%), MINS ([13.0%]; aHR 2.2; 95% CI 1.9–2.6; AF 15.9%), sepsis ([4.5%]; aHR 5.6; 95% CI 4.6–6.8; AF 12.0%).[19] Three of these complications (i.e. major bleeding, MINS, and sepsis) potentially explained 44.9% of the deaths.

In the ASOS cohort, the frequency of severe complications and the independent association with mortality is shown in Table V. Please note that troponin screening was not routine in ASOS (where it was in VISION), therefore the outcomes associated with myocardial infarction will not represent the true incidence, given that the majority of myocardial events are silent in the perioperative period.[20]

The data from ASOS would suggest that the complications resulting in mortality in Africa, may be different to the global predictors of mortality. Africa is predominated by infections. Other groups of complications associated with mortality are cardiorespiratory and renal complications, although the incidence of these complications is lower.

Understanding what complications, and when and where these complications occur will help develop strategies to improve surgical outcomes. Patients die predominantly on the ward in the postoperative period. In the VISION study, death in the operating room was uncommon (i.e. five patients) and accounted for 0.7% of the deaths. In contrast, postoperative mortality was substantial (i.e. 710 deaths), accounting for 99.3% of the deaths.[19] The median time to death was 11 days (IQR 6–19), and the number of deaths was approximately evenly distributed over the 30-day follow-up. 29.4% of the deaths occurred after patients were discharged from the hospital.[19] In ASOS, 239 (2.1%) of 11 193 patients died after surgery, 14 (5.9%) of whom died on the day of surgery, with the remainder postoperatively. Median time of death was five days (IQR 2–11) postoperatively in ASOS.[9]

In summary, most deaths occur postoperatively and occur earlier in Africa, and are predominated by infections. Death following complications is known as 'failure to rescue'. In Africa, this is twice that of the global average. Following elective surgery, mortality following complications in ASOS was 30/620 (4.8%)[9] and in ISOS 207/7 508 (2.8%).[8]

What we need to improve surgical outcomes in low-resource environments

While it is clear that we need to increase the volume and scope of surgery offered in low-resource environments to improve surgical outcomes, it is possible that we could decrease mortality through decreasing 'failure to rescue'. The ASOS-2 trial attempted to do this. In this large cluster randomised trial, we attempted to identify the patients at highest risk of complications and death through risk stratification, using the ASOS Surgical Risk Calculator score,[21] and then focused the limited available care on these high-risk patients by providing enhanced postoperative surveillance in an attempt to decrease failure to rescue. The interventions included: i) admission to higher care ward; ii) increased frequency of nursing observations; iii) assigning the patient to a bed in view of the nursing station; iv) allowing family members to stay with the patient in the ward; and v) placement of a 'postoperative surveillance guide' at the bedside. The teams were advised to offer as many of the interventions for as long as possible postoperatively.

Table V: Complications associated with mortality in the ASOS cohort, when controlled for with the ASOS Surgical Risk Calculator score[21]

Complication	Incidence	Any complication independently associated with mortality	Severe complication independently associated with mortality
Superficial surgical site infection	7.2%	No	No
Deep surgical site infection	3.0%	No	Yes
Body cavity infection	1.1%	No	No
Pneumonia	1.7%	No	Yes
Urinary tract infection	1.0%	Yes	Yes
Bloodstream infection	1.3%	Yes	Yes
Myocardial infarction	0.1%	No	No
Arrhythmia	0.4%	No	No
Cardiac arrest	1.0%	Yes	Yes
Pulmonary oedema	0.3%	No	Yes
Pulmonary embolism	0.1%	Yes	Yes
Stroke	0.2%	No	No
Gastro-intestinal bleed	0.4%	Yes	Yes
Acute kidney injury	1.3%	Yes	Yes
Postoperative bleed	5.1%	No	No
ARDS	0.5%	No	Yes
Anastomotic leak	0.4%	Yes	Yes

We recruited 332 hospitals from 28 African countries between May 2019 and July 2020 with 160 hospitals (13 275 patients) randomised to the enhanced postoperative surveillance arm and 172 hospitals (15 617 patients) to the standard care arm. While we could identify the high-risk surgical patients using the ASOS Surgical Risk Calculator tool,[21] we could not decrease in-hospital mortality with enhanced postoperative surveillance (Relative risk 0.96, 95% CI 0.69–1.33; $p = 0.79$).[22] These findings suggest that a 'generic-fix' is not going to decrease 'failure to rescue'.

A process evaluation was undertaken to understand what really happens on the ground when trying to implement this intervention.[23] What we found was that the implementation of the trial intervention in these resource-limited environments was difficult, and in reality, it outstripped the limited resources at the sites. The big messages were that for an intervention to be implemented in the African resource-limited environment requires: i) leadership (surgical staff enthusiasm, and nursing management support); ii) teamwork (nursing staff and site investigators' contributions); and iii) ensuring that the intervention was 'context appropriate' through context testing. It is currently unclear if the failure to improve outcomes in ASOS-2 was because we failed to implement the intervention, or if we did not have the resources to respond adequately to the patient's deterioration, or interventions to improve outcomes were not initiated.[23]

Conclusion

Health equity will never be achieved until we redress the surgical volume and surgical case-mix available to patients in low-resource environments.

Although patient morbidities are lower in low-resource environments, and complications may occur less frequently, they are associated with increased mortality through 'failure to rescue'.

As clinicians, we first need to prioritise teamwork and leadership, if we are to be able to initiate quality improvement interventions to improve outcomes in low-resource environments.

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