



## Review article: Safety aspects of anesthesia in under-resourced locations

### Article de synthèse: Considérations concernant la sécurité de l'anesthésie dans les régions manquant de ressources

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#### Abstract

**Purpose** *Improving patient safety during anesthesia and surgery is the focus of much effort worldwide. Major advances have occurred since the 1980s, especially in economically advantaged areas. This paper is a review of some of the challenges that face those who work in resource-poor areas of the world.*

**Principal findings** *There is a shortage of trained anesthesia providers, both physician and non-physician, and this is particularly acute outside urban areas. Anesthesia is still sometimes delivered by unqualified people, which results in expected high rates of morbidity and mortality. Residency training programs in low-income countries ought to increase their output as anesthesiologists must be available to supervise non-physician providers. All groups require continuing medical education. In addition, increased efforts are needed to recruit trainees into the specialty of anesthesia and to retain them locally. There is a well-recognized shortage of resources for anesthesia. Consequently, concerted efforts are necessary to ensure reliable supplies of drugs, and attention should be paid to the procurement of anesthesia equipment appropriate for the location. Biomedical support must also be developed. Lifebox is a charitable foundation dedicated to supplying pulse oximeters to low- and middle-income countries. Adoption of the World Health Organization's Surgical Safety Checklist could further reduce morbidity and mortality.*

**Conclusions** *Much time, effort, planning, and resources are required to ensure that anesthesia in low-income areas can reach internationally accepted standards. Such investment in anesthesia would result in wider access to surgical and obstetrical care, and the quality and safety of that care would be much improved.*

#### Résumé

**Objectif** *L'amélioration de la sécurité du patient pendant l'anesthésie et la chirurgie fait l'objet de nombreux efforts partout dans le monde. Des progrès majeurs sont survenus depuis les années 1980, particulièrement dans les régions avantagées d'un point de vue économique. Cet article est une synthèse de certains des défis auxquels font face ceux qui travaillent dans des régions du monde où les ressources sont rares.*

**Constatations principales** *Il existe une pénurie de professionnels formés en anesthésie, qu'il s'agisse de médecins ou de non-médecins, et cette pénurie est particulièrement prononcée à l'extérieur des centres urbains. Il arrive encore que l'anesthésie soit réalisée par des personnes non qualifiées, ce qui entraîne, sans surprise, des taux élevés de morbidité et de mortalité. Les programmes de formation en résidence dans les pays à faible revenu devraient augmenter leur capacité étant donné qu'il faut que des anesthésiologistes soient présents pour superviser les professionnels non-médecins. Tous ces professionnels ont besoin de formation médicale continue. En outre, des efforts supplémentaires sont nécessaires pour recruter des stagiaires dans la spécialité de l'anesthésie et pour les garder au niveau local. Il existe une pénurie bien connue de ressources en anesthésie. Par conséquent, des efforts concertés sont nécessaires afin de garantir un approvisionnement fiable en médicaments, et il faut porter une attention particulière à l'approvisionnement en matériel d'anesthésie adapté au lieu où elle sera pratiquée. Le soutien*

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biomédical doit également être développé. Lifebox est une fondation caritative qui se consacre à la fourniture d'oxymètres de pouls aux pays à faible et moyen revenu. L'adoption de la Liste de contrôle pour la sécurité en chirurgie de l'Organisation mondiale de la Santé pourrait réduire encore plus la morbidité et la mortalité.

**Conclusion** Il faut beaucoup de temps, d'efforts, de planification et de ressources pour garantir que l'anesthésie atteigne des normes acceptées au niveau international dans les régions à faible revenu. Un tel investissement en anesthésie engendrerait un meilleur accès aux soins en chirurgie et en obstétrique, avec une grande amélioration de la qualité et la sécurité de ces soins.

The Merriam-Webster medical dictionary defines *safe* as “not causing harm or injury: having a low incidence of adverse reactions and significant side-effects when adequate instructions for use are given and having a low potential for harm under conditions of widespread availability.”<sup>1</sup> Massive resources are now being devoted to issues of patient safety owing to a report by the Institute of Medicine (IOM) in 1999.<sup>2</sup> The specialty of anesthesia has been a leader in patient safety since long before the IOM report, and many specialty societies developed standards and guidelines for the safe practice of anesthesia in the 1980s.<sup>3-5</sup> The World Federation of Societies of Anaesthesiologists (WFSA) first approved *International Standards for the Safe Practice of Anaesthesia* in 1992. The WFSA updated the standards in 2008 and again in 2010 when they were published in the *Journal*.<sup>6</sup> All of these standards and guidelines are endorsed with the sole aim of making anesthesia safer. This objective has been achieved in many economically sound parts of the world,<sup>7-9</sup> although there is always more to do. Resource-poor regions lag far behind, and there is much to be done before they can achieve these international standards and improve patient safety in anesthesia.

The World Health Organization (WHO) launched its Safe Surgery Saves Lives campaign in 2007. Three themes were defined for that work – clean surgery, safe anesthesia, and safe surgeons.<sup>10</sup> So what are the unique issues relating to anesthesia safety in resource-starved regions?

### Provider shortages

One of the basic recommendations of guidelines to practice is the presence of a trained anesthesia provider.<sup>3,6</sup> There is a critical shortage of trained anesthesia providers in low-income

countries. This includes all providers, not just physicians.<sup>11</sup> Exact numbers are hard to obtain, but Linden *et al.* quote 17 anesthesiologists for all of Uganda with a population of about 33 million.<sup>12</sup> Of 14 district hospitals surveyed, none had an anesthesiologist. On average, there were two mid-level anesthesia providers in each hospital; two hospitals had only an anesthesia assistant, and two lacked any provider at all. Mid-level providers include clinical officers, who have generally received three years of post-secondary training plus a year of sub-specialized training in anesthesia, and anesthesia assistants, who have received 1.5 years of post-secondary training. Similar grades of training, but often with different designations, exist in many areas of the world. Clinical officers or their equivalent provide the backbone of anesthesia services in many countries, but there are significant limitations to their knowledge, skills, and training. Rwanda has similar problems to those in Uganda, with only two expatriate anesthesiologists working in the district hospitals.<sup>13</sup> Spiegel *et al.* showed that none of the 44 primary health facilities in Mongolia had a qualified anesthesiologist or surgeon. Five of the 44 facilities had general doctors providing anesthesia, and ten of the 44 had non-physician providers.<sup>14</sup> In Afghanistan, lack of anesthesia providers in district hospitals results in referral of patients requiring general inhalation anesthesia.<sup>15</sup>

So how do these shortages affect patient safety? In the first instance, if no trained anesthesia provider is available, anesthesia may be given by an individual with no anesthesia training, e.g., a theatre nurse or assistant, or the operating surgeon may administer anesthesia and then proceed with surgery. In either case, the patient is at significant risk for morbidity and mortality.<sup>16</sup> Clinical officers do an admirable job under extraordinarily difficult circumstances; however, their training is limited, and supervision by an anesthesiologist is almost unknown, especially in the district hospitals. The results are well recognized in the high surgical and obstetrical mortality rates.<sup>16-18</sup> Avoidable anesthesia-associated deaths are reported to be as high as 1:150.<sup>18</sup>

### Recruitment, training, and retention

With regard to the overall numbers of anesthesiologists and non-physician providers, attention needs to be devoted to several areas, specifically, recruitment into the specialty of anesthesia, education in anesthesia, and retention in the home country. Work is ongoing in many countries in sub-Saharan Africa to develop residency training programs in anesthesia. These are being supported actively by overseas societies of anesthesia and university departments, e.g., the Canadian Anesthesiologists' Society, the American Society of Anesthesiologists in Rwanda, the Irish College of

Anaesthetists in Malawi, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) in Uganda, Duke University, University of California at San Francisco, and McMaster University, to name just a few. Nevertheless, the numbers of anesthesiologists grow slowly, and attention and support are required for the clinical officers and nurses who are the majority of providers of anesthesia care in the non-urban areas. The WFSA advocates that all anesthesia providers should graduate from an accredited training program,<sup>19</sup> and this is recommended in the International Standards.<sup>6</sup>

The WFSA is active in providing training opportunities in many areas of the world, e.g., in Bangkok, Thailand, for trainees from surrounding countries, such as Laos, Myanmar, Mongolia, and Vietnam. It also offers sub-specialty anesthesia training, e.g., pediatric anesthesia in Vellore, India, with trainees coming from India itself, Bangladesh, and Nepal. Many low-income countries have large pediatric populations so expertise in pediatric anesthesia is vital to the short and long-term development of safe surgery and anesthesia.

Retention of trained providers is a huge problem. Health ministries in low-income countries need to consider developing career pathways that offer satisfaction and challenge to all of their health care workers. The losses in terms of patient care are enormous, but the losses in terms of economics are staggering.<sup>20,21</sup> While losses of physicians are greatest, there are often internal losses of trained anesthesia providers to other types of work and from rural to urban centres.

### Continuing medical education

In countries where resources are limited, access to continuing medical education is problematic. There are not many opportunities, and even when they exist, it is difficult for clinical officers, or even anesthesiologists, to benefit from them. Distances are great and transportation is difficult; the workload is heavy, and it is not easy for practitioners to take a leave of absence. The WFSA and many national societies of anesthesia develop and support continuing medical education courses and workshops. The WFSA also provides educational materials, such as books, on-line tutorials, and CD-ROMs. Nevertheless, a large percentage of trained anesthesia providers have never owned a textbook,<sup>22</sup> have never had the opportunity to read a journal, are unaware of standards and guidelines to practice, and have never been able to update their techniques from those they learned during training. When providers do get the opportunity to attend a workshop or update course, they are extremely receptive to new ideas and techniques. As national and regional societies of

anesthesia develop in low-income countries, they are accepting the challenge of providing continuing medical education for their members. As these grow and mature, significant progress can be made in this area.

Zimmerman describes an innovative continuing medical education effort in Nepal.<sup>23</sup> Although the venture is unrelated to anesthesia, it could easily be applied to the specialty. A seven-module set of programs was produced using case-based learning. At the end of each module, participants have the opportunity to take a multiple-choice examination and fill out an evaluation form to receive credit. The WFSA “Anaesthesia Tutorial of the Week” produces a peer-reviewed tutorial on a variety of topics.<sup>24</sup> The tutorial is Web-based but can be used on mobile phones. A smartphone app is in development. The tutorial begins with a set of multiple-choice questions and ends with a review of important points and a set of references for further reading. Collecting all of these tutorials together (they are archived on the WFSA Web site) would create a virtual textbook. Unfortunately, there are still many anesthesia providers in low-income countries who do not have access to computers or to a reliable Internet connection. As economies improve, easy and low-cost electronic access will become more available, and this method of education will likely become much more important.

### Resources

Even when sufficient trained providers are available, documentation has frequently shown that many essential resources for anesthesia are lacking.<sup>11,22</sup> Hodges *et al.* showed that only 23% of Ugandan hospitals— 48% of which were included in the survey— had the necessities to administer a safe anesthetic to an adult for a laparotomy; 13% of hospitals could administer safe anesthesia to a child, and only 6% could safely anesthetize a mother for a Cesarean delivery with general or spinal anesthesia. Basic items, such as oxygen, electricity, and running water were not always available. Other important deficiencies included pulse oximeters, endotracheal tubes, intravenous fluids, and spinal needles. Frequently, there were no intrathecal drugs available or magnesium sulphate or oxytocin for the parturient. Ketamine was often the only anesthetic agent. Muscle relaxant supplies were unreliable, and access to narcotics was possible for only 45% of anesthetists. The issues are similar all across sub-Saharan Africa. In one region of Tanzania serving four million people, Kimaro showed that only nine hospitals of 27 could give endotracheal anesthesia to an adult and a child with the use of oxygen.<sup>25</sup> In Guinea-Bissau, none of the operating rooms of eight hospitals surveyed had pulse oximeters; only two

of eight hospitals had electrocardiography devices (P. Bael: personal communication).

The WHO has developed a *Guide to Anaesthetic Infrastructure and Supplies at Various Levels of Health Care Facilities*.<sup>26</sup> The guide describes the minimum essential equipment and drugs required to deliver basic anesthesia care. It is clear that many hospitals in low-income countries do not meet these requirements. Considering that emergency obstetric surgery constitutes a large percentage of the surgical volume in district hospitals,<sup>27</sup> it is catastrophic for young mothers not to be able to access safe anesthesia for Cesarean delivery.

A reliable supply of anesthetic drugs is essential for the safe practice of anesthesia. This involves planning and coordination between administration, pharmacy, and anesthesia. It is important for administrators and pharmacists to understand the negative effects of an unreliable supply. It may not be possible to deliver general anesthesia if there is no volatile agent. If ketamine, which seems to be the most reliably available drug,<sup>21</sup> is unavailable, it may not be possible to provide anesthesia at all. Lack of a vasopressor, such as ephedrine, could result in untreatable hypotension following spinal anesthesia for Cesarean delivery and could possibly result in the death of the young mother. Narcotics, even morphine, which is inexpensive, are often in very short supply. There are many reasons for these circumstances, but the end result is patients who are often in severe pain with all of the negative consequences that follow.

### Equipment safety

The safety of available equipment is often in question.<sup>28</sup> Many hospitals are reliant on donated equipment that may not function well in a very different environment.<sup>11</sup> It is rare for hospitals in low-income countries to have biomedical engineering departments so preventive maintenance of anesthetic equipment is almost unheard-of, especially outside of the major centres. When functioning equipment breaks down, it may take months to obtain spare parts. While having poorly functioning anesthetic equipment is a major problem that usually results in dependence on ketamine as the sole anesthetic agent, it is much worse to have unrecognized malfunctioning equipment that can result in overdoses of drugs, e.g., volatile agents, or hypoxia leading to cardiac arrest and death. In North America, prior to the introduction of oxygen alarms and high and low pressure sensors, disasters from hypoxia, ventilation, and disconnect problems were common.<sup>4</sup> Devices that are readily available and consistently used plus the advent of oximetry and capnography have totally

changed the practice of anesthesia in many parts of the world.<sup>29</sup>

It is essential that low-cost safe anesthesia equipment that is suitable for use in austere environments be made available to anesthesia practitioners in low-income countries. This includes anesthesia machines that can function without compressed gases and without complicated systems that depend on a reliable supply of electricity. There are at least two machines designed for use in such environments.<sup>30,31</sup> The International Organization of Standardization (ISO) has recently developed standards for inhalational anesthesia systems in resource-limited areas.<sup>32,33</sup> The Safety and Quality Committee of the WFSA has produced performance requirements for anesthetic equipment that could assist purchasers to ensure they are buying a machine suitable for their particular environment.<sup>34</sup>

### Monitors

Safe and effective monitors are necessary for patients during anesthesia. The “finger on the pulse” is no longer an acceptable standard. Even in the most basic of facilities for the most basic types of surgery, a stethoscope, sphygmomanometer, and pulse oximeter are recommended.<sup>6</sup> Yet even these instruments are not reliably available. The WHO has recognized that pulse oximetry is an essential monitor for patients undergoing anesthesia and surgery.<sup>35</sup> This stand is fully supported by national<sup>5</sup> and international<sup>6</sup> standards and guidelines. Funk *et al.* estimate that there are 77,000 operating rooms in the world where anesthesia and surgery are delivered without the use of pulse oximeters.<sup>36</sup> An enormous international collaborative effort has begun to supply pulse oximeters to those in need. This began with WHO in 2007 and has progressed to the launch in 2010 of a new charitable foundation called Lifebox.<sup>37</sup>

Lifebox has developed a low-cost full-service pulse oximeter that meets or exceeds ISO standards. Every Lifebox that is delivered comes complete with a CD-ROM that includes a variety of educational material in different formats and languages. This material is useful for either self-learning or for group teaching. It includes a video, an instructional manual for the oximeter, PowerPoint presentations describing oxygen transport, case presentations, quizzes, and an algorithm to assist in the management of hypoxia. In addition, the Lifebox team, the WFSA, and anesthesia societies and departments around the world are working together with their colleagues in resource-poor settings to provide courses, workshops, and seminars on pulse oximetry. The anesthesia community has enthusiastically embraced this project and thus far over 3,000 oximeters have been donated (Lifebox: personal communication). Of course, a monitor is only as efficient as the

people who use it; hence, the educational aspect of this project is enormously important. Oximetry is not the answer to all the problems of anesthesia in low-income areas, but it acts as an early warning device for hypoxia. Hopefully, a rapid and appropriate response to a fall in oxygen saturation can assist in reducing morbidity and mortality during and after anesthesia and surgery.

### Checklists

The introduction of a Surgical Safety Checklist (SSCL) has been shown to reduce morbidity and mortality.<sup>38</sup> This is true in well-resourced operating rooms as well as in those with few resources. Therefore, with the introduction of pulse oximeters and the related education, the Lifebox team is also introducing the SSCL. This is a much bigger challenge, as successful use of the SSCL necessitates good teamwork amongst nurses, surgeons, and anesthesia providers. This can be difficult to achieve even in well-run well-organized operating rooms.<sup>39</sup> It is even more challenging in places with few resources and often very unequal professional levels amongst providers. Nevertheless, it is worth striving for its success; the importance of the checklist was appreciated by anesthetic clinical officers who were introduced to it in a workshop in Uganda (I Walker: personal communication). Opening the lines of communication, fostering discussions about patients, and planning ahead should enhance patient safety in any operating room setting.<sup>40</sup>

### Blood supply

There are other important safety issues that are not directly under the control of anesthesia but which make a difference to patients during anesthesia and surgery – the presence of a reliable blood supply is a good example. Many maternal deaths occur secondary to hemorrhage.<sup>14,41</sup> The WHO lists acute hemorrhage as the leading cause of maternal death.<sup>42</sup> It quotes an average maternal mortality rate of 240:100,000 live births in low-income countries compared with a mortality rate of 16:100,000 live births in advantaged locations. The *Fourth Report on Confidential Inquiries into Maternal Deaths in South Africa* stated that “Problems with restoring circulation in bleeding patients remained a serious problem, occurring in 82.1% of women dying of ante-partum haemorrhage and 81.7% of women dying of post-partum haemorrhage.” The inquiry recommends “adequate supplies of resuscitation fluids, blood products, oxytocic agents and surgical equipment.” Anesthesia providers are frequently the people with the most advanced resuscitation skills but they are limited in what they can do without the

necessary fluids, drugs, and equipment. Organizing a blood service takes money, knowledge, and the commitment of many people, but it can make an enormous difference to the survival of patients, especially peripartum and post-trauma.

### Future directions

The future lies in education, specifically education of a sufficient number of anesthesiologists who will develop the academic leadership required for successful training programs in anesthesia, actively supervise and educate non-physician providers, and advocate successfully for the resources required to practice safe anesthesia. It is also vital to educate governments, ministries of health, and administrators about the increasingly important role of anesthesia and surgery for population health. Strategies must be developed to retain health care workers in the areas of need.

### Conclusion

There is much to be done to improve anesthesia safety in under-resourced locations. Until the importance of surgery itself is recognized as a major part of the burden of disease,<sup>43</sup> it is unlikely that the importance of anesthesia will be fully appreciated by those who control the finances and decision-making. There is some indication that attitudes are changing, but there is much to be done to achieve international anesthesia standards and the provision of all aspects of safe anesthesia care.

### Key points

- Anesthetic safety is compromised in low-resource settings due to lack of qualified providers.
- Provision of adequate safe anesthesia is difficult without appropriate resources, i.e., drugs, equipment, and monitors.
- Morbidity and mortality from anesthesia and surgery are very high in low-resource areas.
- Major recruitment efforts are required for anesthesia training programs.
- Retention of trained anesthesia providers is a major challenge.
- Lifebox is a charitable foundation dedicated to providing pulse oximeters to low- and middle-income countries.

- Adoption of the WHO Surgical Safety Checklist should be encouraged.

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