Cardiac Surgery Capacity in Sub-Saharan Africa: Quo Vadis?

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Abstract

Background Current data on cardiac surgery capacity on which to base effective concepts for developing sustainable cardiac surgical programs in Africa are lacking or of low quality.

Methods A questionnaire concerning cardiac surgery in Africa was sent to 29 colleagues—26 cardiac surgeons and 3 cardiologists in 16 countries. Further, data on numbers of surgeons practicing in Africa were retrieved from the Cardiothoracic Surgery Network (CTSNet).

Results There were 25 respondents, yielding a response rate of 86.2%. Three models emerged: the Ghanaian/German model with a senior local consultant surgeon (Model 1); surgeons visiting for a short period to perform humanitarian surgery (Model 2); and expatriate surgeons on contract to develop cardiac programs (Model 3). The 933 cardiothoracic surgeons listed by CTSNet translated into one surgeon per 1.3 million people. In North Africa, the figure was three surgeons per 1 million and in sub-Saharan Africa (SSA), one surgeon per 3.3 million people. The identified 156 cardiac surgeons represented a surgeon to population ratio of 1:5.9 million people. In SSA, the ratio was one surgeon per 14.3 million. In North Africa, it was one surgeon per 1.1 million people. Open heart operations were approximately 12 per million in Africa, 2 per million in SSA, and 92 per million people in North Africa.

Keywords

- cardiac surgery in Africa
- rheumatic and congenital heart surgery
- development models for cardiac programs
- pioneers in cardiac surgery

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Conclusion Cardiothoracic health care delivery would worsen in SSA without the support of humanitarian surgery. Although all three models have potential for success, the Ghanaian/German model has proved to be successful in the long term and could inspire health care policy makers and senior colleagues planning to establish cardiac programs in Africa.

Background

Pioneering of cardiac surgery in north and sub-Saharan African regions began in the 1950s and 1960s.[1–7] Sustainability of the programs in sub-Saharan Africa (SSA) was confounded by multiple problems. It demanded the highest level governmental support, a dedicated multidisciplinary team approach, leadership, and profound know-how which were not adequately available in those days.[8,9]

Cardiac surgery capacity in Africa was reviewed almost 15 years ago by Unger and Turina, and they reported 18 open heart operations per million and 1 cardiothoracic surgeon (CS) per 4 million people.[10,11] In response to this alarming situation, several visiting cardiac teams went to Africa to establish humanitarian cardiac programs or to aid the local cardiothoracic surgical teams who had limited or no capability to perform open heart surgery.[8]

The objectives of the study were to provide baseline data on current cardiac surgery capacity to enable effective concepts to be designed within the priority health care agenda for developing sustainable programs in SSA.

The article will attempt to "formulate new solutions for these very old problems"[11] for colleagues in developing countries, particularly in SSA. It will describe the current role of visiting humanitarian heart teams who come to SSA for 10 to 14 days and the Ghanaian/German and Namibian models for developing cardiac surgery in SSA.

Methods

Participants in the Study

A retrospective survey on cardiac surgery capacity was conducted in 2011 and 2012 in 21 countries in Africa with open heart surgery capability. Survey questions included number of cardiac centers or units in each country, local and visiting surgeons performing open heart and closed heart procedures, diagnostic possibilities, and hospital mortality rates.

Colleagues practicing in these countries were invited to participate in the study. There were six countries in North Africa: Algeria, Morocco, Tunisia (the Maghreb states), Egypt, Libya, and Sudan and 15 countries in SSA: Central Africa: Angola; East Africa: Kenya, Rwanda, Tanzania, Uganda; West Africa: Côte d'Ivoire, Ghana, Nigeria, Senegal; The Horn: Eritrea, Ethiopia; Southern Africa: Mauritius, Mozambique, Namibia, South Africa (Republic of South Africa [RSA]). Mauritius and Nigeria were also invited but did not have the capability to perform regular open heart surgery in 2012.

Finally, 29 senior colleagues (3 cardiologists and 26 cardiac and CSs) representing 16 countries with open heart surgery capability participated in the study. The distribution by regions was as follows: North Africa, $n = 5$; Central Africa, $n = 1$; East Africa, $n = 10$; West Africa, $n = 7$; The Horn, $n = 2$; and Southern Africa, $n = 4$. The database of the Cardiothoracic Surgery Network (CTSNet, www.ctsnet.org) was searched for 933 listed CSs in Africa in April 2013. The data were verified by the executive director, CTSNet. The study differentiated in the listed CS in Africa between surgeons who perform open heart surgery or pure thoracic surgery. The CTSNet registry does not represent the number of global practicing CS; however, it demonstrates the approximate density of CS in various regions.

The principal author of this article undertook exploratory visits to interact with colleagues in Ghana, Libya, Tunisia, Rwanda, South Africa, and Uganda in conjunction with educational meetings. He conducted interviews during the Pan-African Society for Cardiology meeting in Kampala, Uganda in 2011 and at video conferences with colleagues in Kenya and Nigeria during the Pan-African/World Health Summit Global Forum in Berlin in 2012 and 2013. Three models for developing cardiac surgery in SSA were reviewed.

Model 1: Ghanaian–German and Namibian models are associated with an integrated health care system with part government and part private funding managed by a senior local consultant CS. The Ghanaian program, for example, is independent, has political support, has trained more than 20 local and foreign CS, maintains stable surgical load though lower than that of its counterparts in Europe, and produces scientific works. The model requires 7 to 10 years for infrastructure development and stability and 3 more years for the mixed team until the unit becomes independent.[5,9]

Model 2 is practiced in many countries in SSA: Visiting teams (1–2 missions a year) who come for 10 to 14 days are not integrated into the health care system and not fully supported by the host health care policy makers due to economic constraints. This model is solely dependent on foreign donors and would require at least 10 years for developing a proper infrastructure with the local teams. An additional 3 to 5 more years would be required to mentor the local teams as a mixed team until unit independence at 15 years. The expatriate teams commit themselves to teaching the local staff and additionally arrange scholarships with the local health authorities for the local physicians to be sent to high-volume centers for postgraduate training. This has happened in Mozambique where the foreign surgeons have trained a native team including surgeons who now perform more than 100 open heart cases per year.

Model 3 is practiced in Kenya: Senior expatriate CS on contract is paid by the host government to develop a cardiac

surgery program and organize capacity building. This is similar to the cooperation between Deutsches Herzzentrum Berlin and Sarajevo Heart Centre.

Sources of Statistical Data

Annual reports on cardiovascular diseases, data on global population, and health care expenditure statistics were obtained from the Web sites of the World Bank (WB), World Health Organization (WHO) and analyzed. Further data were retrieved from the annual statistical reports of the German Society for Thoracic and Cardiovascular Surgery, Deutscher Herzbericht 2013, p. 202 (Publisher: Deutsche Herzstiftung—German Heart Foundation: www.herzstiftung.de/herzbericht) and a presentation by Prof. Wei Wang, Fuwai Hospital, Beijing, China on behalf of the Chinese Society for Cardiothoracic Surgery during the International Telemedicine Forum held in Berlin on October 23, 2013, in conjunction with the fifth World Health Summit. The gross domestic product (GDP) and GDP per capita of Africa and sub-Saharan African countries were obtained from WB data published in 2012. Global and national mortality data were sourced from the WHO publication 2012.[12–17]

Figures on population of Africa and SSA were used to calculate ratios of (1) cardiothoracic surgeons (CSs), (2) cardiac centers, (3) open heart surgery to population, (4) pediatric cardiologists to population under 15 years, and (5) percentage of pediatric population in SSA that had access to open heart surgery.

The populations of nonparticipating countries were not included in the calculation for heart centers, cardiac surgeons, and open heart surgeries to million population ratios. The population of Africa in 2012 was 1.1 billion. Without Egypt (80.7 million), Sudan (37.2 million), and South Africa (51.2 million), the population was 912.3 million. North Africa has a population of 221 million, without Egypt and Sudan 103.1 million. The population of the Maghreb states was 81.7 million. SSA has a population of 860.4 million, without the RSA (809.2 million).

Hoffman formula was used for calculations to predict the incidence of congenital heart disease (CHD)/1,000 live births, which estimates 4 to 5/1,000 live births. Severe CHD requiring cardiological care occurs in 2.5 to 3/1,000 live births.[18]

Exclusion Criteria

Surgeons who were performing open heart operations irregularly—less than 10 a year—and had not operated in the last 3 consecutive years (2010–2012) were not included in the study. Hospitals or units with a local CS which had limited open heart surgery capability, performing less than 10 operations a year, or no capability for open heart surgery were excluded.

Results

Data were obtained from 25 respondents of the 29 colleagues who were invited for the study, yielding a response rate of 86.2%. Four of the six North African countries (Algeria, Morocco, Tunisia, and Libya) participated in the study yielding a response rate of 66.7%. In SSA, the response rate was 91.3% (21/23).

Using Hoffman model, an estimate of 4.42 to 6 million children in SSA are born with CHD. Of these, an estimated 1.7 to 2.6 million children will require cardiac surgery in SSA. In East Africa, The Horn, and Ghana, 0.5 to 3.4% of the estimated number of children younger than 15 years of age requiring surgery had access to open heart surgery.

There were 78 cardiac centers or units which were performing regular open heart operations in Africa. Distribution by region is as follows: 56 centers in North Africa (the Maghreb states: Algeria, Morocco, and Tunisia) and Libya and 22 in SSA. West Africa, $n = 5$; Central Africa, $n = 1$; East Africa, $n = 12$; The Horn, $n = 2$; and Southern Africa, $n = 2$ (►**Table 1**).

A total of 933 CS in Africa were listed in the CTSNet registry, which translates into one surgeon to 1.3 million people. CS to population ratio was three surgeons per 1 million for North Africa and one surgeon per 3.3 million for SSA (►**Table 2**).

Of the 668 CS in North Africa registered with the CTSNet, 510 originate from Egypt and Sudan. The remaining 158 CSs are practicing in the Maghreb states (Algeria, Morocco, and Tunisia) and Libya.

The number of CS in Africa registered with the CTSNet has increased from 1% of the global population of CS to 2.7% (in figures: from 210 in 2002 to 933 in 2013) during the past (►**Figs. 1–4**) decade. About 67% of the CS are practicing general thoracic surgery or have no capability to perform open heart surgery. In North Africa (Maghreb states and Libya), 36% are practicing general thoracic surgery (►**Fig. 3**).

Table 1 Regional distribution of cardiac centers with capability to perform regular open heart operations in 2012 in North and sub-Saharan Africa

Regions	Cardiac centers (*n*)	Cardiac center per million (*n*)
Africa[a]	113	1:8.5
Africa[b]	78	1:12.5
Sub-Saharan Africa + RSA	57	1:15.1
Sub-Saharan Africa[c]	22	1:33.3
Central Africa	1	1:132
East Africa	12	1:12.4
The Horn	2	1:54.4
West Africa	5	1:63.7
Southern Africa[c]	2	1:50.5
Southern Africa + RSA	37	1:2.7
North Africa	56	1:1.8

Abbreviation: RSA, Republic of South Africa.
[a]Excluding Egypt and Sudan.
[b]Excluding Egypt, Sudan, and RSA.
[c]Excluding RSA.

Table 2 A summary of cardiac surgery capacity in African regions in 2012

(A) Regional distribution of cardiothoracic surgeons and cardiothoracic surgeon to population ratios (CTSNet registry)		
Region	**Cardiothoracic surgeons (CTSNet)**	**Cardiothoracic surgeons per million (CTSNet)**
Africa	933	1:1.3
Sub-Saharan Africa	265	1:3.3
North Africa	668	3:1
(B) Regional distribution of cardiac centers, cardiac center to population ratios, and cardiac surgeons with capability to perform open heart surgery		
Regions	**Cardiac centers *n*, *n* per million**	**Cardiac surgeons with capability to perform open heart operation *n*, *n* per million**
Africa[a]	113, 1:8.5	206, 1:5
Africa[b]	78, 1:12.5	156, 1:5.9
Sub-Saharan Africa[c]	22, 1:33.3	57, 1:14.3
+ RSA	57, 1:15.1	107, 1:8
North Africa	56, 1:1.8	99, 1:1.1
(C) Regional distribution of open heart operations and open heart operations to population ratios		
Regions	**Open heart operations**	**Open heart operations per million**
Africa[a]	14,802	18.6:1
Africa[b]	10,725	11.8:1
Sub-Saharan Africa[c]	1,277	1.6:1
+ RSA (public sector)	4,077	4.7:1
North Africa	9,448	91.6:1

Abbreviations: CTSNet, Cardiothoracic Surgery Network; RSA, Republic of South Africa.
[a]Excluding Egypt and Sudan.
[b]Excluding Egypt, Sudan, and RSA.
[c]Excluding RSA.

There were 156 CS (99 in North Africa and 57 in SSA) identified as having capability to perform open heart surgery in Africa.

Cardiac surgeons in North Africa with capability to perform open heart surgery: In North Africa, 99 CS were performing open heart operations (►**Fig. 3**). CS to population ratio in the North African region was one surgeon per 1 million people (►**Table 2**). In the Maghreb states, it was one surgeon per 1.1 million people.

Cardiac surgeons in SSA with capability to perform open heart surgery: With the exclusion of RSA, a nonparticipant country there remains 97 local CS from SSA registered with the CTSNet (►**Fig. 5**). Of these 97 CS, 32 had capability to perform regular open heart surgery (►**Figs. 5** and **6**, ►**Table 2**). An additional 25 expatriate cardiac surgeons were practicing with the local teams in SSA. The 57 CS

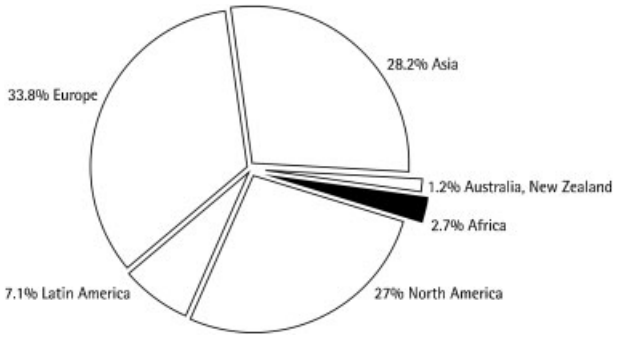

Fig. 1 Global distribution of cardiothoracic surgeons registered with the CTSNet, the Cardiothoracic Surgery Network in April 2013 ($n = 34,251$).

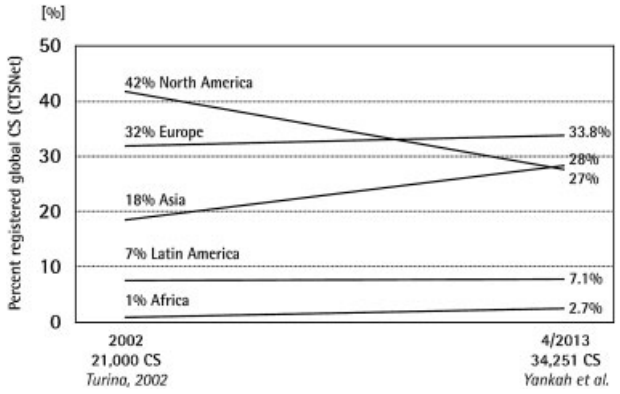

Fig. 2 Global distribution of cardiothoracic surgeons registered with the CTSNet in 2002 ($n = 210$) and 2013 ($n = 933$). CTSNet, Cardiothoracic Surgery Network.

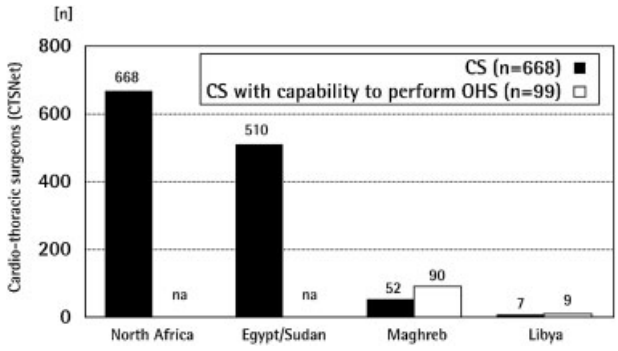

Fig. 3 Cardiothoracic surgeons (CSs) in North Africa registered with the CTSNet in 2013. CS, $n = 668$. CSs with capability to perform open heart surgery (OHS): $n = 99$ (the Maghreb states: $n = 90$, Libya: $n = 9$). Data from Egypt and Sudan were not available (na).

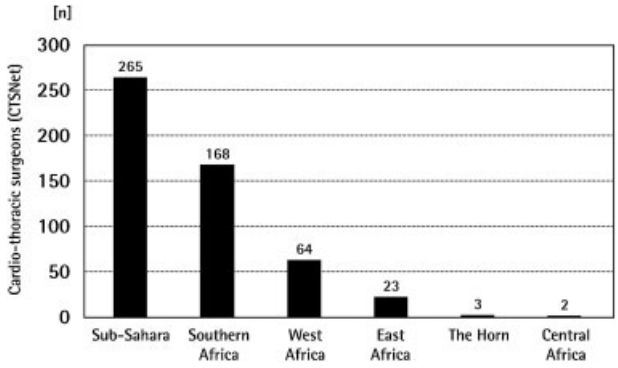

Fig. 4 Regional distribution of cardiothoracic surgeons in sub-Saharan Africa registered with the CTSNet in 2013 ($n = 265$). CTSNet, Cardiothoracic Surgery Network.

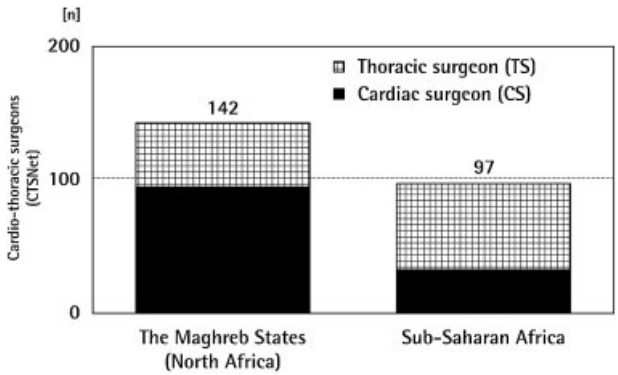

Fig. 5 Cardiothoracic surgeons registered with the CTSNet in Africa in 2013. North Africa (the Maghreb states): $n = 142$. Thoracic surgeons (TS): $n = 52$, cardiac surgeons (CS): $n = 90$. Sub-Saharan Africa excluding RSA: $n = 97$, TS: $n = 65$, CS: $n = 32$. CTSNet, Cardiothoracic Surgery Network; RSA, Republic of South Africa.

practicing in SSA were defined as mixed teams. Cardiac surgeon to population ratio in SSA was 1:14.3 million for the mixed team and 1:25 million people for local cardiac surgeons (►**Fig. 7**).

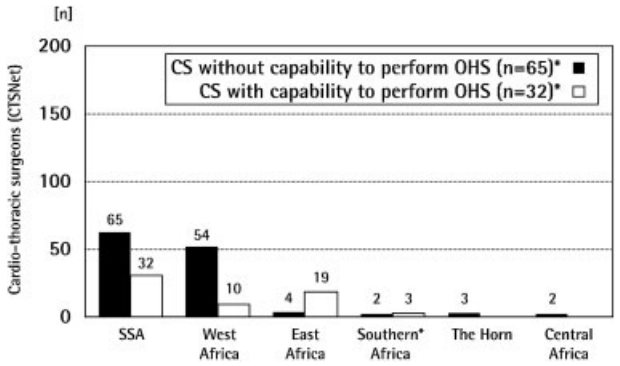

Fig. 6 Local cardiothoracic surgeons in sub-Saharan Africa listed in the CTSNet registry ($n = 97$). Regional distribution of the local cardiothoracic surgeons with capability ($n = 32$) and without capability ($n = 65$) to perform open heart surgery in sub-Saharan Africa excluding RSA*. CTSNet, Cardiothoracic Surgery Network; RSA, Republic of South Africa.

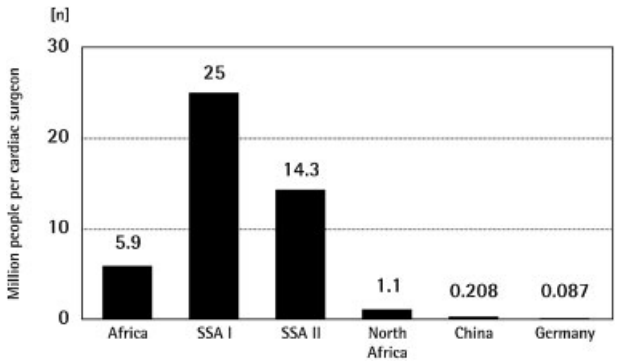

Fig. 7 Population in million per cardiac surgeon. Africa: one cardiac surgeon per 5.9 million people. Sub-Saharan Africa I (SSA I): one local cardiac surgeon per 25 million people, sub-Saharan Africa II (SSA II): local and visiting cardiac surgeons (mixed teams). One cardiac surgeon per 14.3 million people. North Africa: one cardiac surgeon per 1.1 million people. Distribution by regions: Central Africa 1:33 million, East Africa 1:5.1 million, The Horn 1:18.1 million, West Africa 1:26.5 million, Southern Africa 1:16.8 million. China: one cardiac surgeon per 0.208 million (208,333 people), Germany: one cardiac surgeon per 0.087 million (87,723 people).

In 2012, 78 centers performed an estimated 10,725 open heart operations in Africa, which translates into 11.8 open heart operations per million people in Africa. Twenty-two centers in SSA and 56 in North Africa performed 1,277 and 9,448 open heart operations, respectively (►**Fig. 8**, ►**Table 2**). In the Maghreb states, it was 110 open heart operations per million people.

Distribution of open heart operations by regions in SSA was as follows: Central Africa, $n = 255$; East Africa, $n = 362$; The Horn, $n = 81$; West Africa, $n = 377$; and Southern Africa, $n = 202$ (►**Figs. 8** and **9**). Most of the procedures (70%) were performed by the visiting teams.

In East Africa (Kenya, Rwanda, Tanzania, Uganda), 29 CSs (19 locals and 10 expatriates) performed open heart surgery on 362 patients in 2012. In the Horn (Eritrea, Ethiopia), six surgeons operated on 81 patients in 2012. There were 12 open heart operations per million in Eritrea (►**Figs. 8** and **9**).

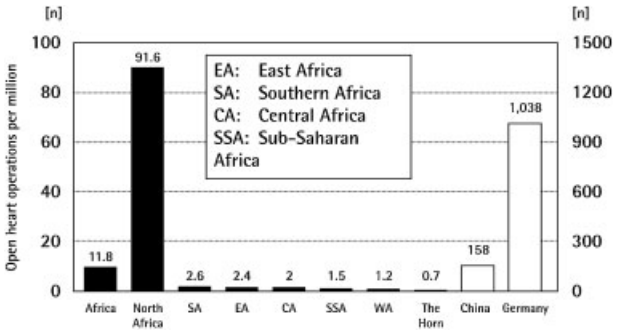

Fig. 8 Regional distribution of open heart operations to population ratio in Africa, China, and Germany in 2012.

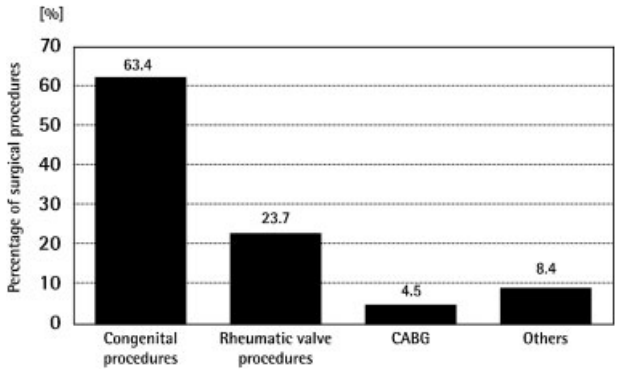

Fig. 10 Distribution of cardiovascular surgical procedures in East Africa and The Horn in 2012, $n = 443$. CABG, coronary artery bypass grafting.

In West Africa, 12 CSs (10 local and 2 expatriate surgeons) were serving a population of 318.6 million and performed 377 open heart operations in 2012 (►**Figs. 8** and **9**).

Central Africa has a population of 132 million and there was no local CS identified. Four visiting cardiac surgeons were practicing in Angola, and performed 255 open heart operations in 2012. This means a CS to population ratio in Central Africa of one per 33 million people (►**Figs. 8** and **9**).

There were six CSs practicing in Southern Africa (excluding RSA). Of these, five visiting cardiac surgeons were practicing in Mozambique and one local surgeon in Namibia. The two institutions performed 202 open heart operations in 2012 in the region (►**Figs. 8** and **9**).

RSA is a continental referral center with approximately 35 heart centers and 50 cardiac surgeons performing approximately 2,800 open heart operations in the public and 5,480 in the private sector a year (data from Prof. Francis Smit, Bloemfontein, South Africa). The estimated data of the public sector in SSA translate into a ratio of five open heart operations per million, one cardiac surgeon per 8 million, and one center per 15 million people. Adding the figures for RSA distorts the data of SSA considerably; their inclusion produces an overall ratio of 20 open heart operations per million people in Africa as a whole.

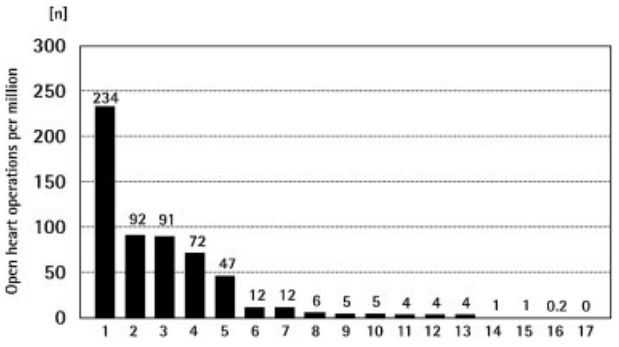

Fig. 9 Distribution of open heart operations to population ratio by countries: (1) Tunisia, (2) Morocco, (3) Algeria, (4) Libya, (5) Namibia, (6) Angola, (7)Eritrea, (8) Senegal, (9) Côte d'Ivoire, (10) Rwanda, (11) Ghana, (12) Kenya, (13) Mozambique, (14) Tanzania, (15) Uganda, (16) Ethiopia, and (17) Nigeria.

On the basis of the data from China and Germany, CS-to-population ratio was one per 208,333 and one per 87,723 people, respectively. China performed 158 and Germany 1,038 open heart operations per million people (►**Figs. 7** and **8**).

The most frequent cardiac procedure performed in 2012 in East Africa and The Horn was congenital heart surgery followed by rheumatic heart valve surgery (10% repair and 90% replacement) and coronary artery bypass surgery (►**Fig. 10**). Among the congenital heart patients, 12% were adults. In the pediatric population, the valve repair rate was 76%.

Early (30-day) mortality: The overall mortality of the pediatric cases of the visiting teams in SSA ranged from 2 to 4%.

The three models were used for developing cardiac programs in SSA. In Model 1 (Ghanaian–German, Namibian), a senior local consultant CS with governmental and private foundation funding developed national capacity building programs. Model 2 has been used in 21 centers. Visiting teams are funded by NGOs and charged with local staff training. Model 3 is used in Kenya. It is a modification of Model 1 where in the absence of an indigenous senior local consultant CS with managerial talent, the senior CS is an expatriate on contract.

Discussion

The study results represent the most comprehensive data till date on the current state and practice of cardiac surgery in SSA. RSA is a total outlier vis-a-vis the rest of SSA with respect to availability of cardiac surgery services. Inclusion of its data would have distorted the data of SSA considerably and is not really relevant to the main point of the publication.

Twenty-two centers in SSA performed 1,277 open heart operations in 2012 which translated to 1.6 (approximately two operations) per 1 million people. Most of the centers offer open heart surgery to pediatric patients in collaboration with foreign visiting teams who come for 10 to 14 days with the exception of units in Ghana, Namibia, and RSA which are operated independently by local staff.

The data published in this article proclaim an urgent need for long-term strategic plans to train local surgeons and allied personnel at home and abroad for developing existing cardiac programs. Currently, except in Ghana the accredited institutions of the West African College of Surgeons in Liberia, Nigeria, Sierra Leone, and the Gambia would need foreign support to facilitate cardiothoracic surgery training programs.[5,19] Cardiac and thoracic surgeries are regarded as one specialty; therefore, the College facilitates combined training and certification. In order not to repeat the mistakes made in the developed countries, catheter-based interventional procedures and echocardiography courses should be part of the curriculum which will prepare trainees to be integrated into a heart team working group. In East Africa, there is an accredited teaching hospital for cardiothoracic surgery training only in Kenya. The median length of cardiothoracic surgery training in West Africa is 6 years. West African residents obtain much less hands-on experience compared with their European and American counterparts.[20] A young cardiothoracic surgeon in SSA therefore does not meet the requirements for board certification in Europe and therefore might need to go elsewhere for additional surgical skill training. This critical situation can be improved by developing close collaboration with visiting teams in various African regions and encouraging them to become involved in the cardiac surgery training programs. Unfortunately, the fellowship programs in cardiothoracic surgery in India and RSA for trainees from SSA which began with great enthusiasm and promise have lost their momentum and practical value and need to be revisited on a governmental level. The flaw is attributed to lack of strategic planning with the policy makers and bench marking of the training program.

In Africa, only 51.4% of the CS registered with the CTSNet performed open heart surgery in 2012. In North Africa, it was 62.6% and in the SSA, it was 33%. The CS in SSA are challenged with a high number of patients and late referrals requiring surgery for congenital heart, rheumatic heart valve, and coronary artery diseases.[5,21–24]

The Ghanaian–German model has demonstrated that the determinant factor for sustainability of a cardiac surgery program in SSA is leadership rather than the distribution of health expenditure per capita income and the GDP. The density of the CSs could be directly related to the distribution of GDP and the health budget, but it was not a determinant factor for sustainability and success of the cardiac programs.[5,11]

In some regions, there is currently no substitute for visiting heart teams and this is not likely to change in the near future. Aldo Castaneda properly defined the efficiency of visiting heart teams: "It helps if an experienced (± senior/retired) surgeon leads these efforts on a full time, pro bono basis."[8] The model is similar to that initiated in 1989 by Frimpong-Boateng in Ghana under the mentorship and sponsorship of Hans Borst and the former President of Ghana, Jerry Rawlings.[5] This Ghanaian/German model has proved to be a successful program in the long term and could inspire health care policy makers in SSA and senior colleagues planning to establish cardiac programs in their home countries. Ghana cannot currently afford a second independent cardiac center for its 25 million population for economic reasons although it is urgently needed. It is therefore applying Model 2 to develop a second center in Kumasi which is completely dependent on two visiting teams (adult and pediatric) from United States. This model is being practiced in Kenya as well with a team from the United Kingdom.

One solution to the acute shortage of cardiac surgical services in SSA is to engage foreign teams to support the local teams to develop a program on a "twinning" basis.[25] Critics of humanitarian surgery emphasize the challenges facing the local teams after departure of the visiting teams.[9,11] Late postoperative care has proved to be one of the biggest challenges because many of the adult patients are taking warfarin for anticoagulation after receiving mechanical heart valves. Financial constraints around clinic and hospital visits and admission have prevented some patients from receiving appropriate care in a timely fashion, again, most critically, in the vulnerable first few weeks after surgery. Alternative biological valves should be considered in a selected group of patients in such situations.[26,27]

A long-term solution to this problem is to convince the ministers of health and education to commit the deans of the national university medical schools to begin putting together resources for more robust postoperative care, to include (1) training of nurses and general practitioners in basic cardiology concepts and warfarin management, (2) echocardiography courses for personnel from provincial and district hospitals where cardiac patients are being seen, to improve cardiac care in the country. The Berlin initiative of monthly international video clinical conferences with African countries which are practicing cardiac surgery can strengthen the networking and collaboration in continuing education with centers in Africa.

The data provided in ►**Figs. 6–8** demonstrate the great difference in cardiac surgery services between the emerging, developed and developing economies.[17] The figures from the Maghreb countries in North Africa (Algeria, Morocco, and Tunisia) could inspire the policy makers and the colleagues in SSA to target at least 92 to 110 open heart operations per million in the future. Nigeria has a population of 168.8 million and if it completes the reactivation of its five to seven existing centers in the next 10 years, West Africa will possess 12 centers to serve the region of 318.4 million. Ghana and Nigeria could aim at performing 30% of the projected 2,500 and 17,000 open heart operations per annum in the next decade, respectively. Kenya could aim at performing 30% of the projected 4,400 open heart operations per annum. The cardiac team in Eritrea could plan for 500 open heart operations a year in the Horn region in the next decade. The 12 centers in East Africa (Kenya, Rwanda, Tanzania, Uganda), the two centers in the Horn (Eritrea, Ethiopia), and the two other centers in Southern Africa (Mozambique, Namibia) could aim at performing 30 to 50 open heart operations per million in the next two decades.

Limitations of the Study

Patients' demographics were not available. The high-volume centers in Egypt and Sudan which perform more than 1,000 to

1,500 cases each per year did not participate in the study. The data presented in the study contain no late clinical results.

Conclusion

Cardiothoracic health care delivery would worsen in certain regions in SSA without the support of humanitarian teams. The Ghanaian/German model has proved to be a successful program in the long term and could inspire health care policy makers in SSA and senior colleagues planning to establish cardiac programs in Africa.

Strategic plans for training programs in high-volume centers are critical to populate SSA with adequate CS in the next three decades with international support.

The programs should aim at developing a database to support clinical research and educational programs. An endowment of a heart foundation to supplement the government's budget for maintaining the infrastructure of the program is the driving force for sustainability of the cardiac program.

A sustainable cardiac program demands highest level governmental support, leadership, and a dedicated multidisciplinary team with profound know-how.

The length of time for cardiac missions should be extended to 21 days and this is desirable to integrate a special "task force" for postoperative management and skill training programs.

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