Title

“Advanced Medical Technologies Management in Limited Resources Settings Context: a 5 years’ Experience from the Cardiac Centre of Shisong in Cameroon”

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Abstract
The Cardiac Centre Shisong (CCS) is the reference centre for the cardiovascular diseases care in Central Africa. The technical /operational experience for the medical technology management capitalized in the CCS could be useful as “model of cooperation” between NGO and developing countries.

The philosophy leading the project can be described in 3 axes:
- Providing quality and affordable care to the populations
- Empowering local personnel
- Model of management providing that the CCS must be 100% managed by local people and possibly economically sustainable

Materials and Methods:
The primary issues faced in the CCS were:
- The limited offer of the local market (spare part, devices, equipment, consumables)
- Huge instability of basic utilities (Electricity, Water)
- Need of skilled personnel.
- Absence of reliable companies to take care of most of the medical equipment in Cameroon.

The strategies to overcome these issues have being:
- Training for the local personnel
- Helpdesk office
- Supervision on site by Europeans expert during the first years
- Collaboration with European NGO and companies for free certified technical services
- An adapted medical equipment management philosophy
- Fund raising in Europe to support the main projects

Results & Conclusions
- 95% of In house maintenance
- Quality and safety of equipment confirmed by certified checks
- Daily users checks prevent 80% of medical equipment failure during use.
- Trainings and collaborations of local technicians with the manufacturers permitted to reduce the maintenance cost and avoid expensive maintenance contract for 98% of our equipments.
- Optimization of logistics is essential.
- Strong and stable basic utilities (Energy, Water,) are a necessity.
In Central Africa (over 250 millions inhabitants), the Cardiac Centre Shisong (CCS) is a reference centre for the cardiovascular diseases care. This hospital is the fruit of the collaboration of 3 main actors which are: “Tertiary Sister of St Francis” (Cameroon), “Bambini Cardiopatici nel Mondo” Italian Onlus, “Cuore Fratello” Italian Onlus. The technical /operational experience for the high medical technology management capitalized in the Cardiac Centre could be useful as “model of cooperation” between NGO and developing countries.

Figure 1: Shisong Location in Central Africa [1]
A. Background:
The project started up in 2002 as a cardiology ambulatory in the Saint Elisabeth Catholic General Hospital. The training of Cardiologists / Surgeon / Nurses in Italy at Poli Clinic San Donato Milan was initiated the same year. All urgent cases for children surgery from CCS were treated in San Donato Poli Clinic, Milan.

The Design and Construction of the CCS started from 2005 to November 2009. It was inaugurated in November 19th 2009 and first surgery in the center was performed the day after. Since November 2015, the Shisong Cardiac Centre has been raised to the status of public utility by Cameroon’s Head of state [1,2].

The philosophy leading the project can be described in 3 axes:
- Providing quality and affordable care to the populations for cardiovascular diseases with a particular attention to the pediatric and to the underprivileged patients
- Empowering local personnel
- Develop and obtain a model of management providing that the CCS must be 100% managed by local people and possibly economically sustainable

A.1 Roles of Partners
The three partners of the project CCS had precise roles.

Table 1: Roles of partners [1]

<table>
<thead>
<tr>
<th>Tertiary Sister of St. Francis, Cameroon</th>
<th>Bambini Cardiopatici nel Mondo, Onlus</th>
<th>Cuore Fratello, Onlus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of the local Personnel for training in Europe (23)</td>
<td>Training of the local personnel in Europe</td>
<td>Accommodations for Patients to be operated and Cameroonian personnel to be trained in Italy</td>
</tr>
<tr>
<td>Selection of Patients (130)</td>
<td>Surgical Interventions in Italy and Missions in CCS since the inauguration.</td>
<td>Sponsorship for 130 heart surgical operation in Italy from 2004/2009. Fund raising for surgical operation for underprivileged patients.</td>
</tr>
<tr>
<td>Funding of the Building works (1600k€)</td>
<td>Medical Equipment Supply (1950k€)</td>
<td>Funding of the basic utilities plans (1650k€)</td>
</tr>
</tbody>
</table>
A.2 Initial Phase of Construction

Figure 2: During the Construction Phase [1]

A.3 Initial Phase of Training

Table 2: Training of Local personnel in Europe [2]

<table>
<thead>
<tr>
<th>TRAINING FOR</th>
<th>Nº Doctors</th>
<th>Nº Nurses / Perfusionists</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery</td>
<td>2 (San Donato)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrophysiology</td>
<td>1 (San Donato)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interventional Cardiology</td>
<td>1 (San Donato)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perfusionist</td>
<td></td>
<td>2 (San Donato)</td>
<td></td>
</tr>
<tr>
<td>Cardiac Surgery Scrub</td>
<td></td>
<td>2 (San Donato)</td>
<td></td>
</tr>
<tr>
<td>Intensive Care</td>
<td></td>
<td>6 (San Donato / Hesperia )</td>
<td></td>
</tr>
<tr>
<td>Anesthesia</td>
<td></td>
<td>1 (San Donato)</td>
<td></td>
</tr>
<tr>
<td>Blood Bank</td>
<td></td>
<td>1 (San Donato)</td>
<td></td>
</tr>
<tr>
<td>Angiography + U.S machine</td>
<td></td>
<td></td>
<td>2 (Belgium)</td>
</tr>
<tr>
<td>Medical Equipments</td>
<td></td>
<td></td>
<td>1 (Italy)</td>
</tr>
</tbody>
</table>

Figure 3: Training of Technicians and Packing of Medical Equipment for CCS [3]
B. Materials and Methods:
The primary issues faced in the CCS on the technologies point of view were:
- The limited offer of the local market (spare part, devices, consumables)
- Huge instability of basic utilities (Electricity, Water)
- Huge need of skilled personnel.
- Absence of reliable companies to take care of most of the medical equipment in Cameroon.

B.1 Strategies for the Hospital Technologies Management
Some strategies have being developed over the years in order to see that the philosophy of the hospital become a reality.
- Training for the local technicians Helpdesk office (Senior Engineers which facilitate the technology management by using their worldwide professional network to advise the local technicians). This help to facilitate the access to quality materials, to the best prices, fastest services, to trainings for the local technicians in Europe, to improvement of technical relationship through the partecipation to international technical Association in order to be constantly updated on new technologies and related aspects.
  - Supervision on site by Europeans experts during the first years
  - Collaboration with European NGO and companies offering certified free services as: Annual quality control, electrical safety checks, repair of components, donation of spare parts and equipment
  - Fund raising in Europe to support the main projects.

B.2 Management Philosophy for New and Certified refurbished Medical Equipment (ME)
They are the main type of equipment for invasive and critical clinical activities. The followings are the main focus for critical equipment
- Health technology assessment (adequacy with the local environment, cost and sustainability, impact on existing healthcare status)
- User & Technician Trainings by manufacturer’s experts on site or in Europe
- Availability of Documentation (User, service manuals; software)
- Protocol for Medical staff: User Check (Elaborated by local technician)
- Preventive maintenance plan
- Spare Parts / Cannibalizing: as the brand new spare part are very expensive some second hand equipment are bought from specialized organization (example: BITEB in Italy). These equipment are used as source of spare part (case of extracorporeal circulation machine Stockert SIII) this help to save up to 70% of the cost of the spare part budget thus maintaining the same equipment clinical outcome.
- Reference formal and informal Collaborators (Technicians and companies) for all the equipment

B.3 Management Philosophy for second hand and non critical equipment
They are the main type of equipment for non invasive and not critical clinical activities. The following list constitutes the lifecycle of this category of equipment
  - Selection: based on the Quality of the results and Cost Analysis
  - Verification: if the spare parts are available and if the equipment is still in production.
  - Free functioning check by a collaborator expert technician before purchasing
  - Documentation research
  - Procurement and Transportation to Cameroon
  - Local technical check and installation to be used back up for critical Medical Device (Anaesthesia, respirators…) or in case of failure of the principal equipment, second hand devices can be used while servicing the main equipment. If needed they can be used also as spare part source to repair the main equipment.
  - Regular User / Technician Checks
Some activities are performed on a yearly base by technicians independently of the category of the equipment:
  - Preventive Maintenance & Quality Control
  - Free annual functioning and electrical safety tests by external company with certified tools.
Figure 4: Open Heart Surgery in Cardiac Centre Shisong [3]

Figure 5: Nurse performing the medical equipment user checks before an intervention
C. **Results:** Cardiac Center's basic construction, Medical Devices, medical and surgical data

Table 3: Hospital Data 2009 – 2015 [2]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Superficies</td>
<td>12.200mq</td>
</tr>
<tr>
<td>Total area of buildings</td>
<td>2.200mq</td>
</tr>
<tr>
<td>Green area</td>
<td>800mq</td>
</tr>
<tr>
<td>Number of beds</td>
<td>73 beds</td>
</tr>
<tr>
<td>Open heart surgery</td>
<td>553</td>
</tr>
<tr>
<td>Hemodynamic &amp; electrophysiology</td>
<td>507</td>
</tr>
<tr>
<td>Consultations</td>
<td>44,142</td>
</tr>
<tr>
<td>In Patients</td>
<td>6,777</td>
</tr>
</tbody>
</table>

- Strong and stable basic utilities:
  - Water Cathment installation was made to capture water from mountain sources and channel it to the hospital; Water Treatment System to obtain demineralized pure water for sterilization and medical staff scrubbing
  - Presence of a 630kVA 3 phases main stabilizer and uninterruptible power supply for the operating theater, Intensive Care Unit, Blood bank unit and Angiography

- 498 medical devices & medical equipment.

- The actual local technical staff is at a satisfactory level of expertise. There are agreements with local Universities for the professional training of their students and technical training are planned yearly c/o suppliers in Europe.

- 98% MD are not under a maintenance contract

- 54% of the Medical Devices (MD) purchased since 2009 were brand new or certified refurbished
  - 53% are still perfectly functioning and 1% of them (4 equipment) are temporarily out of use.

- 5 of the new equipment parts have been sent to an expert collaborator company for free maintenance

- 46% of the MD in use are second hand (Purchase value = 135.000 € Real Value = 350.000€)

- 75% Problems are detected during pre-use functional checks

- 95% In House Preventive or corrective maintenance

- 65% MD failures are resolved within 24 hours

- From 2012 to 2015: Second Hand DM Purchasing and donation =12 000 € Real Value = 115.000€
- Electrical safety and functional checks (2009 -2013) shown:
  18 Non Conformity with standard (CEI, Italian Committee for Electrotechnic) CEI 62.5
  - CEI 62.148 have being noticed and corrected.
  - 21 second hand equipments have being cannibalized

**Freezer & Refrigerators**

95% of Problems detected by users during daily checks

10 interventions /month

**Patients Monitor, Ventilators, Anesthesia, Ultrasound, Angiography machines**

52% of Problems detected by users

40% by Clinical Engineering staff

8% by Partners

> 45 intervention / month

**Sterilizers**

70% of Problems detected by users

30% during periodic checks by Clinical Engineering staff

15 interventions /month

**ECG, Defibrillators**

70% of problems detected by users are setting issues

25% are related to their batteries

Over the last years improvements have being noticed:

- 100% Quality Blood & Drugs cold storage insured
- Huge reduction of MD faults during their use
- Better knowledge of visual, functional pre-use checks
- Huge Decrease in the MD out of use time due to maintenance delay (the spare part store is more up to date and a general knowledge of maintenance is increasing).
- Improved collaboration with > 8 Suppliers Technical Experts for our MD
D. **Discussions:**

**D.1 About Technologies management**

Standard methods for preventive activities are highly useful (Electrical safety, Functional checks) to insure the quality / Safety of new MD and Second hand MD which are used as replacement equipment and as source of spare part for many equipment out of production.

In our remote area context, simple and oriented Users Checks forms helps:

- To reduce the MD fault during their use
- To detect very early the faults and react promptly
- To improve the users knowledge about the MD

The optimization of logistics (Packing, Shipping, and Collection) costs is really important when technologies are transferred in developing countries.

Strong and stable Installations (Energy, Water, medical Gases) are an absolute necessity.

The collaboration of skilled local technicians with manufacturer’s experts is the key for a successful advanced medical technology management. In the same line, the remote diagnosis control of equipment by some suppliers is a great asset for the management of complex technologies in remote area.

The training of local technicians by the manufacturers has permitted to reduce the cost of maintenance of equipment and avoid paying for expensive maintenance contract for 95% of our equipments.

Some difficulties and unexpected findings remain permanent challenges:

- Limited Finances due to the fact that more than 40% of patients are not able to pay their bills after surgical interventions.
- High Turnover of nursing staff which implies a need of continuous training on ME use and obviously the existence of faults that could be prevent with a better knowledge from the user.
- Lack of manufacturers or suppliers of spare parts in Cameroon after 7 years of existence of CCS for 50% of our equipment.
- Many second hand equipment & consumables going out of production which implies lack-high cost of spares part (cannibalizing some equipment to repair others); some European teams coming to work with us face some difficulties with technologies they are not used to.
- Lack of information from manufacturer’s as we don’t have a maintenance contract, we sometime receive important information about the changes late.
- The completion of full equipped test laboratory for calibration and repairing of most critical equipment is still ongoing as the cost of the quality tools is quite significant.
- The Centre is not having a central location in the country. Consequently, the distance from the main cities and particularly the very poor public transports and bad road situation is still an unsolved issue which increases the complexity of material, drug, and spare parts logistics.

**D.2 About the Main Partners**

1- The project CCS started under the firm belief that the Center after construction and start period of one/two years could be fully managed by the local people trained in Europe by the Association Bambini Cardiopatici nel Mondo ONLUS c.o. Policlinico di S.Donato (High school of Cardiology and Cardiovascular Surgery) and Cuore Fratello ONLUS for Technical supervision, design, construction and logistic aspects. The CCS Cameroon management team is now supported by a Technical advisor’s committee composed by representatives of the former partners. This committee made of 1 Coordinator, 1 financial advisor, 1 legal advisor, 1 fund raising advisor, 1 technical advisor, 3 medical advisors (one of whom must be working on the spot), 1 scientific advisor, and 3 TSSF representatives. The technical committee is actually coordinated by a Cameroonian medical doctor with a huge experience in Cameroon’s public health.

2- The TSSF congregation has a leading active role in construction utilizing as much as possible local material and thinking as well to the operation and maintenance through a deep benchmark of local construction distributors. They believed in capacities build up for local engineer; respecting as much as possible the local mentality. They integrated the CCS to the existing general which was already recognized and known in the country.

The fantastic results of the local personnel trained in Europe since the beginning of the project allowed the partners:

a. to better know each other and to understand the real needs and the local mentality / custom which are extremely important for an appropriate project.

b. To realize that the Centre; after a first period from the inauguration; is fully managed and operated since 3 years by local people trained in Europe and that the
cooperation and implementation of experience is continuously improved at international level in a network which is amplified day by day.

**D.3 About the Stakeholders**

In the Central Africa there is an increase of cardiovascular diseases and congenital cardiovascular diseases among the baby / children - which in the puberty can became cause of death. The cost of surgical operation in Europe is quite high and it is difficult as well for the population to take care of the indirect cost (visa, transport, lodging etc.). The CCS gives hope to the over 200 million inhabitants; who could need specialized cardiovascular care and who are not able to afford the cost of a treatment in Europe.

Many stakeholders have been involved:

- Presidency of the State, The Ministry of public Health, The Ministry of Finances: The government has always sustained the CCS Project through custom duty exoneration for medical devices, equipment, material importations; funding; training of medical CCS future cardiologist.

- Local Authorities: Major of Kumbo, Traditional Chief of Kumbo and the population have always accepted and facilitated CCS activities; events and supported financially the project.

- Cardiologists local associations have been collaborating to the project through scientific researches and patients referrals.

- Public Benefactors since the beginning are financing the surgical interventions, the acquisition of some equipment: Local Rotary Clubs, Italian Rotary Club Milano Nord Est 2041 District, MIDO, Cuore Fratello, Capuccins Friars… they realize special fund raising for the CCS.

- Private Benefactors: Many personalities and collaborators regularly donate to the Social Case Management Office of the CCS in order to finance interventions for underprivileged patients. The Social Case Office sponsors every year 70 - 80% of surgical interventions, Hemodynamic and Electrophysiology interventions.
E. Conclusions:

This CCS philosophy of technology management has a great impact in reducing the overall cost of specialized healthcare (Yearly ME Maintenance Cost < 3% of ME Value) to the patients who are coming from all Cameroon regions and neighbouring countries (Congo, Guinea, Gabon, Nigeria…).

Empowering local personnel permit a real transfer of knowledge / expertise, thus contributing to fight against poverty in rural area. This solution is not specific to the CCS but absolutely require committed local staff to succeed.

The CCS project key factors are:

- Assurance of the Salary payment which is a great motivation for the workers in developing countries
- National & International Networking: Use of professional relations in every field: cardiology, surgery, engineering in order to have the most affordable solution while maintaining a high quality level.
- Personnel Training: Presence of Skilled local professional in all sensitive area of CCS
- Cameroonian government involvement to sustain the CCS by giving yearly subventions to finance transportation of cardiovascular diseases screening team; by facilitating importation of materials, equipment and drugs; by developing a scientific partnership between universities and hospitals for the training of young Cameroonian technicians and doctors in the CCS.

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