LAUTECH JOURNAL OF ENGINEERING AND TECHNOLOGY 4(1) 2007: 58 - 62

TECHNICAL NOTE

ENGINEERING FABRICATION IN NIGERIAN RURAL MEDICAL PRACTICE - THE ERUWA EXPERIENCE

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Introduction

From the stone age to the digital age, engineering science has been the catalyst for modernization. It is difficult to imagine the world without electricity and the wheel in their different forms. Engineering science has found applications in all facets of human life; from sports to warfare and from the provision of leisure to fighting diseases in the fields of health care.

Scientists are always asking questions and seeking answers to them. We are always proffering solutions to problems that face mankind. It is inevitable that in the course of our work and research we will generate other problems (which in medical practice, we call iatrogenic) and raise more questions thereby creating an endless chain like a nuclear reaction.

On the first page of an authoritative reference book of surgical practice, *Current Surgical Diagnosis and Treatment* the editors wrote: 'The surgeon must be a doctor in the old-fashioned sense, an applied scientist, an ENGINEER, an artist, and a minister to his or her fellow human beings (Dunphy and Way, 1994).

Although engineers do not have direct contact with patients, they are charged with the construction, repair and maintenance of the buildings, all pieces of equipment, instruments and the infrastructural facilities in the hospital without which the surgeon and other professionals in the health team cannot perform their duties effectively.

The Surgeon as an Engineer

In his day-to-day operations on patients, the surgeon is performing one engineering manoeuvre or the other: **removal** of lumps, bumps and diseased parts; **augmentation, reduction, repair** and **grafting** of tissues and organs; **diversion** and **shunting** of the flow of various internal body fluids; **replacement** of organs and tissues with natural substitutes or artificial devices and **breaking up** of stones in some organs. These procedures have similarities in engineering practice: **bulldozing** of hills, **diversion** of roads, **shunting** of circuits, **filling** of potholes, **construction of bridges** across rivers, lagoons and swamps, **dynamiting** of rocks and others. In summary, as there are civil, mechanical, electrical, electronics and chemical engineers, so the surgeon is a **medical** engineer.

In this respect, from the days of antiquity, surgeons have designed and produced the instruments and machines they use in treating patients and such have been named after them. For example, different types of scissors were designed by Mayo and M^{c}Indoe, the retractors of Volkmann, Langenbeck, Czerny, Morris, Joll, Deaver and Doyen; the tissue forceps of Allis, Lane and Babcock. The heart-lung machine used in performing open-heart surgery is a composite system of oxygenators designed by Gibbon and DeWall and the roller pump of DeBakey

In Nigeria, Sir Samuel Manuwa designed the 'excision knife' for tropical ulcers (Adeloye, 2006), Odugbesan[a] (1982), an anaesthetist, designed and produced a neurosurgical operating table and the bolster for gynaecological operations (Odugbesan[b], 1982); retired Brigadier-General Ogbaje, an Army doctor, has produced a blood transfusion kit that won an international prize.

In all of these instances, the driving spirit has always been the solution of problems that militate against the health of human beings and for me the implicit confidence that all my teachers at Ibadan were world-renowned and could train their kind solely in Nigeria.

Another source of inspiration was the 'Red Devil', the battle tank of the Biafrans that was deployed in battle from Aba, where it was made, until it got stuck at Ore during the civil war, 1967 - 1970. I had inspected the disabled Land Rover-turned-battle tank at Ore and concluded that Nigerians could solve all their problems with little or no external help.

The third inspiration was that I have always looked forward to a day like this when everything I am to talk about is homegrown in Ibadan and Ibarapa district with no foreign influence whatsoever. Although I had several opportunities to travel abroad for undergraduate and postgraduate training, I journeyed out of Nigeria for the first time in 1995. That was 20 years after becoming a medical officer and 12 years of being a rural surgeon (Awojobi, 2005).

That was the stage set-up when I arrived Eruwa in August 1983 as a Consultant Surgeon at the District Hospital. The over twenty-three-year sojourn can be divided into two disproportionate periods: the first three years, 1983 – 1986, at the government District Hospital, Eruwa and the remaining 20 years in a private practice, Awojobi Clinic Eruwa.

What are the engineering problems I have faced in the last twenty-three years and what have been my solutions to them? Are there problems or questions created as a result of these endeavours?

Infrastructure

The initial challenges to a successful medical practice in Eruwa were in the infrastructure in the hospital.

Water Supply

The first problem I faced was the gross inadequacy of water supply- that source of life and the indispensable infrastructure in any hospital worth that name. At that time, it was the system of bowls and buckets for most part of the day. This was surely unacceptable in the delivery room and the theatre.

Water supply from the works was intermittent and with the 90,000 litre overhead reservoir it was not possible to provide water round the clock without running the risk of having no water in reserve when there was failure at the works. This situation was recurrent with shortage of chemicals and erratic power supply being frequent occurrences.

Over the three-year period I worked at the district hospital, we built a series of secondary reservoirs using metal drums and cement blocks all with a total capacity of 30,000 litres. They were connected to gutters attached to the eaves to collect rainwater. Thus, all the wards, theatre, kitchen and laboratory had their own reservoirs providing water from the taps all the time. The main reservoir could serve us for about three weeks without water works pumping.

In January 1985, we constructed a deep well to provide another source of portable water. To facilitate water distribution we purchased a hand pump and a gasoline pump, which lifted water into the various reservoirs. All constructions had been through direct labour using hospital personnel and artisans in the neighborhood (Awojobi, 1986).

At our permanent site, throughout the rainy season that spans April to October, all the rainwater falling on all roofs is collected in concrete reservoirs from cement gutters at roof level. A 30 000 litre reservoir will satisfy our requirement till January after which we resort to pumping of water from six deep wells sunk in the valley using a portable pump. Thus we do not rely on the municipal water supply.

If this system is adopted in homes, factories and public buildings, the demand on municipal water supply will be greatly reduced thereby prolonging the lifespan of water pumps and reducing the expenditure on water treatment chemicals. This arrangement is operational at the Baptist Medical Centre, Ogbomoso.

Recently, we have constructed an earthen dam across the seasonal stream that runs through the clinic, all in an effort to make us sufficient in water supply. We have populated the dam with fish to control mosquito breeding and provide protein for the patients and staff.

Energy Supply and Lighting

Another initial problem at the District Hospital was electricity supply. Two 25kVA generators were installed at the inception of the hospital in 1970. One broke down in 1978 and its parts cannibalized to maintain the second, the functioning of which was unreliable and expensive. In the light of this, we launched an appeal fund for a new generator in March 1984. Seven months later, we bought a 5kVA diesel generator at six thousand naira (N6 000.00) mainly from operation fees and the appeal fund. This generator was capable of providing the essential electrical needs of the hospital except x-ray service.

At Awojobi Clinic Eruwa, we have fabricated several 2kVA to 10kVA generators locally to provide electricity for various functions of the hospital (including X-ray services) such that our daily consumption of diesel was just a gallon during the six-year period, 1995 – 2001, when there was no electricity supply from national grid.

Recently, the inverter came into use. This is a device that converts the direct voltage of the car battery to the alternating voltage of the national grid or the electricity generator. We bought an imported brand for N75 000.00 two years ago. However, I am happy to inform you that a young Nigerian Polytechnic graduate, Mr Bola Adeniyi, who works in Ikenne, Ogun State, has produced a reliable version that costs a third of the imported brand. So, when we operate at night, we do not need to put on the generator and there is no longer the danger of Power Holding Company of Nigeria holding us to ransom!!

At Awojobi Clinic Eruwa, the buildings are constructed with large windows so that natural lighting

is adequate to perform surgery in the daytime. Ventilation is good and obviates the need for fans and air conditioners. In the construction of our latest buildings, the ceiling of the rooms which have hitherto being horizontal are now parallel and near to the roof, drastically reducing the attic and thus increasing the volume and airspace of the room. The room that was rectangular is now trapezoid.

We have fabricated a coal furnace that is more efficient than the diesel or gas burner to operate the autoclave and the distiller. The principle utilized is to increase the supply of oxygen to a burning material to ensure complete combustion as exemplified in the laboratory Bunsen burner, the blacksmith's and aluminium smelter's furnace. This is achieved by blowing air continuously into the fire. Recently, the readily available sawdust has become the source of fuel.

Sewage disposal

Human waste disposal at the government hospital had been hazardous until June 1984, when, with the aid of Ibadan medical students on posting to the hospital, we completed the construction of a three-compartment ventilation-improved pit (VIP) latrine for the use of our patients and members of staff. The water closet system installed at the inception of the hospital was inappropriate culturally and unworkable in the face of inadequate water supply.

At present, we are constructing a students' hostel where the water used in the bathroom will be channeled to flush the sewage in the toilets to the septic tank. The toilets have installed in them closet bowls with the water trap removed.

Equipment

- The **operating table** was built in 1986. It is sturdy, has the basic tilts required by the surgeon namely: elevation and depression using the hydraulic jerk of the motorcar, Tredenlenburg tilts, neck flexion and extension and the lithotomy break. It can be fixed with our adaptation of the Mayo trolley which we call Olumide's table – after the medical officer, my student, who suggested it. It is made of 90% wood and 10% metal, covered with formica to improve its aesthesis and allow washing down. In 1986, it cost me five hundred naira (N500.00) to build the table while the imported brand made of cast iron cost seventy five thousand naira (N75 000.00) (Awojobi, 1994). This table was a prize – winning project at the "Innovation of the Year" competition organized by Ikeja Jaycees.
- The **autoclave** is the indispensable machine of the surgeon. It is used to sterilize the equipment and linen the surgeon uses when performing operations. It is made from the 50kg domestic cooking gas with plumbing fittings to let out the pressurized steam which is the sterilizing agent. A gauge at the top measures the pressure in the cylinder. It takes 20 minutes for the pressure to build up to 20lb/square in at which point all the contents are sterile. Thus, we could be performing surgery non-stop if gowns and other linen are available. Its function is similar to the kitchen pressure cooker.
- The **water distiller** is made from an aluminium cylinder made by the local aluminium smelter, galvanized plumbing pipes and helical copper tubing immersed in a water-cooled condenser. Water is distilled at the rate of 10 litres an hour (Awojobi, 1993). Both the autoclave and distiller are powered by the coal/wood furnace. The water distiller was a prize-winning project at a competition organized by the National Agency for Science and Engineering Infrastructure in 1992.
- The **pedal suction pump** is fabricated from a 2 inch plumbing pipe, a piece of leather and a reversed bicycle valve. This equipment is used during surgery and when resuscitating newborn babies and unconscious patients.
- **The haematocrit centrifuge** is an important equipment in medical practice. It is used to determine the packed cell volume, PCV, of the blood of a patient. The PCV is a measure of how many red cells (the oxygen carriers of the blood) a patient has. We fabricated an electric centrifuge from the kitchen blender by stepping down the input voltage to 120V thereby reducing the very high speed of the blender to an appropriate level. However, during the difficult six years we did not have electricity from the national grid and the cost of fuel and generators was prohibitive, we fashioned a manual centrifuge from the rear wheel of the bicycle. It works on the principle of velocity ratio and the centrifugal force generated in a circular motion. The disc revolves at 5400 rpm (equivalent to a force of 3 360g) enough to pack the red cells in five minutes (Awojobi, 2002).

A reviewer of the article on the bicycle haematocrit centrifuge for TROPICAL DOCTOR, a journal of the Royal Society of Medicine in the United Kingdom, wrote: 'the author is to be congratulated for designing this piece of equipment'. He went on: 'I admire the ingenuity....'

The glass capillary tubes which contain the samples of blood to be spun are often sealed with plasticine at one end but when we ran out of plasticine, the cheap and readily available candle wax has proved just as effective (Awojobi and Muyibi, 2002)

- **Intravenous fluid** therapy is lifesaving in many clinical situations especially surgical. However, the fluid must be available when needed in adequate quantity to ensure successful treatment. Until recently much of the intravenous fluid in the country was imported and costly on the open market. This has resulted in its scarcity in the peripheral health units

with attendant morbidity and mortality in patients requiring intravenous fluid therapy.

In 1984, two of my surgical patients (one elective and the other emergency) died from inadequate fluid therapy. So we launched into intravenous fluid production along the lines described by Maurice King in his very handy and practical book "Medical Care in Developing Countries" (King, 1966; (Awojobi et al., 1985).

We should remember that the UCH, Ibadan used to produce all the intravenous infusions it needed when we were medical students in the 70's.

To date we have produced 54 430 litres of normal saline, 3 550 units of acid citrate dextrose solution for blood transfusion and 1 900 litres of 25% dextrose, all at 10% of the cost on the open market.

- **Histopathology service**

One problem associated with the decline in the teaching hospitals was the gross delay in obtaining histopathology reports on operative specimens. By August 2003, we had 49 outstanding reports at the University College Hospital, UCH, Ibadan Pathology Department dating back to 2001. We had paid one thousand five hundred naira (N1 500.00) for each specimen. Again, we have overcome that bottleneck by procuring the microtome and other accessories to produce the slides. Technicians who are holders of National Diploma in Science Laboratory Technology of the Polytechnics have processed 900 specimens to date, most of which originated from our patients, and a pathologist in UCH reads the slides for us. Results are available within 10 days of obtaining the specimen by the routine we have established.

We have adapted the ordinary candle wax to replace the standard paraffin wax for making blocks of the tissue, the surgical or razor blade has replaced the imported microtome blade and a small kerosene stove has taken the place of the electric hot plate for fixing the slices to the glass slides. The candle wax and surgical/razor blade are much cheaper but just as effective as the imported substitutes.

Transportation.

A major problem in health care delivery in rural areas is transportation. Poor and expensive transportation system deters the patients from seeking medical help in time. We have contrived a tricycle from the conventional motorcycle and adapted it for a village ambulance. The vehicle is stable and easily manoeuvrable even on rugged roads. We call it KEKE ERUWA or AUTONOV – 3. Autonovs 1 and 2 were the inventions of my elder brother, Professor Ayodele Awojobi, a mathematician, a mechanical engineer and a social activist of the University of Lagos in the seventies and early eighties.

Research in the Rural Setting.

The Alma Ata report (Primary Health Care, 1978) on primary health care emphasized research and evaluation by those providing the service, those using them and those responsible for managerial and technical control at various levels of the health system.

While the unavailability of modern technology has limited the scope of research, it is still possible to conduct appropriate, "low-tech," and relevant research that is subject to excellent study design, proper controls, and scientifically valid interpretations (Ajayi and Adebamowo, 1999).

Professor E A Elebute, in the maiden Faculty of Surgery Lecture of the National Postgraduate Medical College of Nigeria in February 1988 wrote: "We must work out through research, ways of assessing and thereby improving the quality of care that we give our patients. There are three approaches to the problem of quality of care. The most basic is paying attention to structural aspects such as financial resources, facilities (e.g. water and electricity), equipment and staff. I think most of Awojobi's work in Eruwa is in this direction and he has been able to fashion equipment from locally available materials and device treatment manoeuvres suited to the structural background of his working environment." (Elebute, 1988).

All these fabrications and devices have been published in learned medical journals (Awojobi, 1994; Awojobi, 1993; Awojobi[a,b], 2002; King, 1966; PHC, 1985; Awojobi, 1990).

Conclusion

The overall effects of providing this comprehensive health service in a rural area are (a) surgical care is brought to the door steps of the populace, (b) enhancement of social stability, (c) reduction in medical bills and risks involved in travelling to tertiary centers for care and (d) creation of job opportunities for members of the health team and the supporting professions.

Above all, it brings immense satisfaction to the health providers working amongst the poor rural majority.

As to the last question: 'Are there problems or questions created as a result of this endeavour?, I wish to humbly submit that no problem has been created by this endeavour rather it has raised the question, which science does all the time and which my teachers, Professors A Adeloye and O O Ajayi have put thus: 'The challenge Dr Awojobi faces is how his creative genius and sense of community commitment will pass on to younger generations (Adeloye, 2006; Ajayi, 2001).

References

Adeloye A Current status of neurological surgery in Africa. 14th Sir Samuel Manuwa Memorial Lecture. West African College of Surgeons, 46th Annual Scientific Conference, Accra, Ghana, 7th February 2006.

Ajayi O O and Adebamowo C A Surgery in Nigeria. Arch Surg 1999; 134: 206 – 211.

Ajayi O O Personal communication, 2001.

Awojobi O A, Fayanjuola A A, Awe T A et al. Letter. Intravenous normal saline preparation. A district hospital experience. Nig Med Pract 1985; 10: 119.

Awojobi OA Appropriate technology and management practice in Nigerian rural health care delivery- the Eruwa experience. Polytech J Sci Tech 1990; 1: 1-6.

Awojobi OA Object lessons in making a district hospital work. Afr Health 1986; 8: 34-35.

Awojobi OA The hospital still. Trop Doct. 1993; 23: 173-174.

Awojobi OA Appropriate technology for operating tables. Afr Health 1994; 16: 17-19.

Awojobi[a] OA The manual haematocrit centrifuge. Trop Doct 2002; 32: 168

Awojobi OA and Muyibi SA Letter. When there is no plasticine Trop Doct 2002; 32: 250.

Awojobi O A The travails of rural surgery in Nigeria and the triumph of pragmatism. The 3rd Surgery Guest Lecture, Department of Surgery, Obafemi Awolowo College of Health Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria. 13th December 2005.

Dunphy J E and Way L W. Approach to the surgical patient. In: Current Surgical Diagnosis and Treatment. Ed. Way L W. Appleton and Lange, 1994, Norwall, Connecticut, USA. page 1.

Elebute E A Surgery in Nigeria: The Will and the Way. First Faculty of Surgery Lecture. National Postgraduate Medical College of Nigeria. 16th September 1988.

King M. The preparation of intravenous solution. In: Medical Care in Developing Countries. M King (editor) Oxford University Press, Nairobi PP 30.1b-2 – 30:3, 1966.

Odugbesan[a] C O. An instrument table for use in neurosurgery and neuroanaesthesia. Nig Med J 1982; 12: 125 – 126.

Odugbesan[b] C O Bolsters for use in the operating theatre. Nig Med J 1982; 12: 127 – 128.

Primary Health Care. Report of the International Conference on Primary Health Care, Alma-Ata, USSR, 1978.