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# Introduction of a Hybrid Tele-oncology Program in a Low-Resource Setting in Sub-Saharan Africa

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**Abstract:** Cameroon Oncology Center (COC) is a modern oncology center that was commissioned for clinical use in 2019. COC is located just outside the city of Douala in the Republic of Cameroon in the central African sub-region in Sub-Saharan Africa. With the scarcity of qualified cancer treatment health professionals, COC has had to develop and deplore a hybrid telemedicine program for her oncology services. This paper describes the tele-oncology workflow with particular emphasis on radiotherapy. The oncology telemedicine model consists of a team of US-based experts supported by an onsite team in Cameroon. The team in Cameroon provides face-to-face consultations and clinical evaluation of patients, review of pertinent medical history and pathology, provides initial dose prescription based on accepted protocols, performs computed tomography simulation, radiation treatment delivery, quality control of radiation equipment and patient treatment, evaluations and monitoring during and post treatment consultations. The US-based team oversees treatment planning including contouring of the cancer and delineation of critical structures, computation and review of patient treatment plan, and transfer of approved plan to Cameroon for treatment delivery. With the presented telemedicine model, COC is able to provide high-quality radiation treatments to cancer patients in central Africa that is comparable to any international standard at a fraction of the cost for patients. With increased access to well-trained and experienced professionals, telemedicine is an effective tool to offer quality assured and safe radiotherapy to cancer patients in a resource-limited oncology setting.

**Keywords:** Cancer, Cameroon Oncology Center, Telemedicine, Radiation Treatment Planning

## 1. Introduction

According to the International Agency for Research on Cancer (IARC), cancer currently ranks as a leading cause of death in the world, accounting to about 10 million deaths in 2020 with lung, colorectal, liver, stomach, and breast being the most common causes of the cancer deaths [1, 2]. It is projected that the global burden of cancer will increase steeply over the next decades, with the highest increases predicted to occur in lower-resource countries (that is, countries currently assigned a low or medium Human Development Index) [1, 3]. These developing countries are known to have weak health infrastructure especially in Sub-Saharan Africa (SSA), and sparse cancer services [4, 5]. The IARC GLOBOCAN 2020 data show further that cancer deaths in Africa are now higher than those observed in other

regions of the world [1]. The figures show a cancer incidence of approximately 1.1 million new cases per year, with about 711,000 deaths (64.1% deaths relative to incidence) in Africa, compared to the world statistics of 19.3 million cancer cases and 10 million deaths (51.8% deaths relative to incidence). In SSA alone, the estimated number of new cancer cases in 2020 was about 801,000 with approximately 520,000 deaths (almost 65% deaths relative to incidence) [1, 2, 6]. With a projected doubling of the incidence of all cancers combined by 2070 relative to 2020 [3], Sub-Saharan African countries would have to prioritize and accelerate resource-appropriate cancer control policies to handle the anticipated heavy cancer patient load.

Radiation therapy (RT) is one of the major ways of treating cancer either alone or combined with chemotherapy and/or surgery. The medical linear accelerator (linac) is the modern equipment of choice for the delivery of RT worldwide. If the linac availability is used as an indicator for access to RT in a given region, then Africa (with a current population of about 1.3 billion) is known to have sparse RT services with more than half of the countries in SSA having no RT facility. A recent assessment of RT resources in Africa using information from the International Atomic Energy Agency's Directory of Radiotherapy Centres (DIRAC) database showed that there were only 412 teletherapy units available in Africa in 2021 with 54% of the facilities concentrated either in southern Africa (in South Africa) or northern Africa (in Egypt) [7].

One major challenge that has hindered the development of RT facilities in SSA is that RT involves huge capital investment. It also requires well-trained professionals that take years to train. The setting up of a RT facility requires a large initial capital investment. Incorporating the construction of radiation oncology center can literally lead to a significant reduction of other health programs. Additionally, the lack of local training facilities for oncology personnel means that these personnel would need to be trained out of the country. This takes time and increases the cost of implementing a RT program. In response to the rising burden of cancer and shortage of RT facilities in Sub-Saharan African countries, our institution, Cameroon Oncology Center (COC), recently implemented a RT program based on linac technology. Being a resource-constrained oncology centre in the central African sub-region in SSA, COC championed the use of telemedicine in RT treatment planning to ensure the provision of high-quality radiation treatment to cancer patients without compromising patient care. The implementation of telemedicine in response to the scarcity of skilled personnel and various resources is feasible since telemedicine describes long distance communication between medical centres and can thus provide medical services through telecommunication technology [8–13]. That is, telemedicine uses modern communication tools to deliver medical care when the physician and patient are separated by distance. Moreover, the concept of a tele-radiotherapy network has been proposed to be adopted in developing countries to enable RT centres to share and optimally use their infrastructure and staffing resources [5].

The purpose of this paper is to describe the patient workflow employing tele-oncology at Cameroon Oncology Center. As employed in the present work, telemedicine describes the use of medical information transferred from one location to the other through electronic communications to provide high-quality health care to the patient [10].

## 2. Cameroon Oncology Center

Cameroon Oncology Center is a 5000 $m^2$ medical facility situated on the outskirts of the metropolitan city of Douala in the Littoral Region of the Republic of Cameroon. Commissioned for clinical used in 2019, COC is a revenue neutral private oncology center that treats cancer patients from all over Cameroon and all the six neighbouring countries including Nigeria, Chad, Congo Brazzaville, Equatorial Guinea, Central Africa Republic, Gabon, and the Democratic Republic of Congo. The center has two radiation bunkers although presently only one is in use. Also, the center has an outpatient chemotherapy infusion room with eight chairs and twenty private room suites for hospitalization and chemotherapy infusion when required. The Republic of Cameroon has a population of 28 million inhabitants and the number of patients living with cancer at any given time is about 30,000.

The first radiotherapy patient received treatment on April 1$^{st}$, 2019 on a computer-controlled Varian Clinac 21EX linac (Varian Medical Systems, Palo Alto, CA) which has the capability of producing 6 MV and 18 MV photon beams, and five electron energies ranging from 6–20 MeV. The linac is capable of running both regular intensity modulated radiation therapy (IMRT) treatments and constant dose rate dynamic arc therapy. COC is the first and currently the only cancer centre in Cameroon to operate a linac for the delivery of radiation treatments but there is Co-60 teletherapy unit at the government owned General Hospital of Douala.

Cameroon Oncology Center presently does not offer any major surgical or pathology services so prospective cancer patients must bring all the relevant medical information with them to build their medical files. Patients who come to the center requiring biopsy are referred to an outside health facility. COC has a clinical laboratory for tests and is able to run a number of cancer biomarkers. We have about 10 nurses, 4 general physicians, 3 radiation therapists, and 4 radiation therapists in training. The patient daily volumes vary from a low of 10 to 55 patients being treated on the linac. We perform about 50 chemotherapy sessions per month.

## 3. Treatment Flowchart and Radiation Telemedicine Process

The oncology telemedicine model consists of a team of US-based experts (radiation oncologists, medical

oncologists, medical physicists and dosimetrists) supported by an onsite team in Cameroon (medical oncologists, radiation oncologists, medical physicists and a host of other healthcare professionals like nurses and radiation therapists). The hybrid telemedicine program for radiotherapy starts with a patient visiting the center for consultation with the view of being treated. Each patient treated at COC with RT undergoes the following 10 steps which form the basis of our tele-oncology program as shown in Table 1.

***Table 1.*** *Tele-radiotherapy workflow.*

| Step No. | Name | Brief description |
|---|---|---|
| 1 | Clinical evaluation | Evaluation of patient to determine the best care. Assessment of the tumor and staging. Clinical evaluation is performed by either the consultant medical oncologist or radiation oncologist assisted by our general physicians and nurses. |
| 2 | Therapeutic decision making | Selection of treatment goals (cure or palliation) and initial dose prescription. This is determined by the radiation or medical oncologist in Cameroon but the radiation dose is initially prescribed by the radiation oncologist. An initial pro forma invoice is then generated for the cost of treatment based on this assessment. If the patient agrees and pays a certain percentage of the cost of treatment then the patient moves to the next step. |
| 3 | Creation of an electronic medical chart for the patient | An electronic medical chart is created for the patient and this chart is shared with the USA team. The most important components of the electronic record include the consultation report, pathology report, previous CT or MRI report, a CT simulation order, and other relevant reports of previous treatment and laboratory tests performed recently. This is done in Cameroon. |
| 4 | CT simulations and immobilization fabrication | After evaluation and if radiation therapy is chosen as a form of therapy, the radiation oncologist would complete a *CT Simulation Order form*. This form allows the radiation therapy team to simulate the patient and construct any immobilization devices required. The CT simulation order will state the radiation oncologist intent, total dose, dose per fraction and any other relevant information. |
| 5 | Radiation treatment planning | Up to this point, there is generally no intervention from the US team except when the Cameroonian based team specifically asks for a second opinion. After CT simulation, the CT data set is transferred to our computerized radiation treatment planning system located in the United States. The treatment planning for each patient is performed by a board certified medical physicist under the supervision of a board certified radiation oncologist who outlines the GTV and reviews the contours for other critical structures. The treatment planning team uses the same criteria as they would normally use for other patients being treated in the US based on QUANTEC, RTOG or other US nationally accepted protocols/criteria. |
| 6 | Plan processing and sending of plan to Cameroon | Once the treatment plan is approved, it is sent to Cameroon for treatment delivery. If there is a change in dose or fraction from the standard dose fractionation pattern agreed upon, then this is communicated with the radiation team in Cameroon. |
| 7 | Plan quality assurance | The plan is received by the onsite medical physicist and imported into the record and verify system and run to ensure that the patient can be treated with no issue. The plan is printed and signoff by the onsite radiation oncologist and the patient is called for treatment. |
| 8 | Initial verification of treatment set-up with portal filming | On the first day of treatment, the patient is ported and the images are reviewed by the onsite oncologist, medical physicist and the chief radiation therapist. Patient setup is then approved for daily treatment. |
| 9 | Daily treatment on the linear accelerator | The patient continues treatment while being monitored for side effects by the Cameroon team. |
| 10 | Post-treatment evaluation and continuous follow-up | Evaluation of tumor control and assessment of complications during follow-up visits and consultation. |

***Table 2.*** *Simulation Order form.*

| **Patient Names:** | | **Date of Birth:** | | **Date today:** |
|---|---|---|---|---|
| Treatment Site: | | Stage: | | Proposed start date: |
| Total Dose: | | Dose per Fraction: | | Number of Fraction: |
| Radiation Oncologist: | | Date: | | Signature: |
| Treatment Type | ☐ Primary | ☐ Boost | ☐ Resim | ☐ Resim Eval Only |
| Treatment Technique | ☐ 3D Conformal | ☐ IMRT | ☐ 2D | ☐ Electrons |
| | ☐ Supine | ☐ Prone | ☐ Decubitus | ☐ Breast head turned away) |
| Patient Position | ☐ Arms Up | ☐ Arms Down | ☐ Frog Leg | ☐ Head Hyper-extended |
| | ☐ Breast Board | ☐ Head and Shoulders Mask | ☐ Special Board | Others: |
| Contrast and Markers | ☐ Bladder Full | ☐ Wire Scars | ☐ Oral Contrast | ☐ IV Contrast |
| | ☐ Bladder Empty | | ☐ Bolus | ☐ Mark Anal Verge |
| Physics/Dosimetry | ☐ Study | ☐ MRI Fusion | ☐ Prior CT Fusion | |
| | ☐ Study Date | ☐ Special Physics Consult | ☐ Weekly Physics Check | ☐ Final Physics Check |
| Reason for Special Medical Physics Consult | ☐ Patient has Pacemaker or defibrillator or ICD implant<br>☐ Previous Radiation Treatment/dose accumulation and or image fusion | | | |
| Special Treatment Procedure (if applicable) | ☐ Concurrent Chemo radiotherapy ☐ SBRT in place of HDR for cervix cancer<br>☐ Previous Radiation Treatment | | | |
| Portal Imaging | ☐ 1x Weekly ☐ Daily ☐ 2x Weekly: Other comments | | | |

Generally, the patient is referred from any hospital or the patient may just walk in for consultation. Our workflow begins with the patient getting registered by our front desk staff and then they proceed to pay the consultation fees after which they are received by our trained nursing staff who, review their medical history and take down a few important notes for the physician. We have a three-page health questionnaire which the nurse helps the patient to complete which then forms part of the patient medical record. The patient may proceed to see the specialist directly if s/he is free or is seen by the general physician (GP) who goes through the patient history with the patient. The GP then discusses the case with the specialist before the patient sees the specialist. The patient sees either the medical or radiation oncologist first and then is referred to see the second specialist after consulting with the first. The patient most of the times sees the radiation oncologist first and then the radiation oncologist then discusses the case with the medical oncologist before the patient sees her. If the patient's recent diagnostic CT scan is more than two months old, then the patient will be required to have TAP (thorax, abdomen and pelvic) scan with contrast to check for metastasis. The patients may also be required to have an MRI brain scan depending on many factors. Since this is quite expensive for the patient, only selected cases are referred for MRI brain, spine or pelvis scans. With no nuclear medicine procedure in the country, this is the best that can be done. Once the diagnostic TAP scan is out, then the radiation oncologist may order radiotherapy for the patient. S/he would then sign the Patient Simulation Order form as shown in Table 2.

Signing of the order form is done by the Cameroon-based radiation oncologist. The patient then takes the order form to the cashier who then generates a pro forma invoice that covers the cost of treatment which includes CT simulation, treatment planning, and treatment delivery on the linac. The patient may take the pro forma invoice to the chief operating officer for a discount. Less than 10% of the patients pay 100% of the pro forma invoice value. A payment plan is agreed upon with the patient and the patient is allowed to go for CT simulation. The therapist staff may then fabricate mask if it would be required, for instance, for head and neck cancers. The patient is simulated and the CT dataset is uploaded into our treatment planning system computer for treatment planning. A consultation report is also prepared by the radiation oncologist in Cameroon and uploaded for review by the radiation team in the USA. Enclosed with the consultation report will be the CT simulation order form, a copy of pathology report and recent TAP scan report. Treatment planning would continue in the USA as described in Table 1.

Cameroon Oncology Center has implemented prescription protocol as outlined in Table 3. The protocol includes the technique used and some general information about the chemotherapy regimen if used. As Table 3 shows, most of our patients at COC are treated with the IMRT technique except for breast patients. Even cervical cancer patients are treated with IMRT for the whole pelvis phase of the radiation with stereotactic body radiation therapy (SBRT) for boost plan in place of brachytherapy since brachytherapy is currently not available. After completion of treatment, the patient is then scheduled for the first follow-up which usually happens within a month of the patient receiving radiotherapy. The nurse navigator usually will call patients live in other regions of Cameroon or even in other countries for an over phone evaluation.

***Table 3.*** *Radiation prescription protocol used by Cameroon Oncology Center.*

| Type of cancer | Standard fractionation and total dose | Common chemotherapy protocols and cycles (first line)- Generally based on NCCN guidelines | Radiotherapy technique |
|---|---|---|---|
| Prostate | 76 Gy in 38. Salvage radiation therapy for prostatectomy failure is 66 Gy in 33 fractions. | N/A | IMRT |
| Breast | 50 Gy in 25 fractions followed by 10 Gy boost in 5 fractions with electrons. | N/A | 3D Conformal RT (Field in Field technique) |
| Cervix | 2.0 Gy x 23 or 25 fractions for a total of 46-50 Gy plus SBRT boost (3 Gy x 9) or occasionally 5 Gy x 5 fractions. | Cisplatin based chemotherapy | 3D Conformal for initial early stage or IMRT (if treating nodes) but always IMRT boost |
| Head and neck | 70 Gy in 35 fractions<br>66 Gy in 33 fractions | Cisplatin | Always IMRT |
| Lung | 60 Gy in 30 fractions | Cisplatin and vinorelbine | 3D Conformal or low modulation IMRT |
| Rectum | 2.0 Gy x 25 fractions plus boost of 6-9 Gy to the primary site.<br>SIB is also performed 1.8 and 2.2 Gy | Possible surgery after radiotherapy. This is normally not done so we treat to about 60 Gy.<br>F5FU or zalodae | 3D Conformal or IMRT depending on the stage of the disease cancer with IMRT being used with later stage disease |
| Pancreas | 50.4 Gy in 1.8 Gy x 28 fractions | Cisplatin & gemcitabine | IMRT |
| Sarcoma | 2.0 Gy x 25 fractions for preoperative radiotherapy<br>2.0 Gy x 33 fractions for soft tissue extremity sarcoma | Multi agent chemotherapy protocol | IMRT or 3D Conformal RT |
| Esophagus | 1.8 Gy x 28 fractions (radiation alone) or 1.8 Gy x 23 fractions for chemo/radiation | Cisplatin | IMRT |

# 4. Challenges and How We Are Planning to Overcome Them

1) The major challenge we face in the delivery of high-quality radiotherapy is the inability for the patients to pay for their treatment cost. With no public health insurance program in place, medical insurance coverage is very limited and hence patients must pay out of pocket and sometimes patients take months to save the money needed for their treatment and unfortunately their cancer keeps advancing. Our prices range between $0 to about $3000 (US) with the average being between $2500 for curative treatment and about $800 for palliative treatment ranging from 5 to 10 fractions. Despite this low price, less than 10% of the patients we see can afford to pay these fees. This cost normally does not include chemotherapy or the weekly labs that may be needed or CT scans needed to monitor treatment progress. A feasible solution is for the Cameroon government to introduce a national health insurance scheme and to subsidise radiation treatment of cancer based on modern technology.
2) The second major issue is that even if the patients can afford the treatment, they may be unable to afford accommodation close by the center for the duration of their treatment. The cost of accommodation can be as much as $1000 for a course of RT lasting 6-9 weeks. Currently, Cameroon Cancer Foundation is raising funds to build and equip a hostel, which will house about 30 RT patients at a projected monthly rate of $50 (US).
3) Most of the cancer patients received at COC come with advanced cases, which are more difficult and expensive to treat. The government of Cameroon already has a cancer-screening program for common cancer like breast, cervix and prostate but this program needs to be expanded and made more comprehensive.
4) Uncertainty: Clinically, our greatest problem has been the lack of reliable histo-pathology services in Cameroon. This is not a problem for Cameroon alone as most countries in SSA lack pathologists. Obtaining a repeat biopsy or a second opinion for a biopsy may take another 2-8 weeks. The slides are not always available to get a second opinion. Even when the biopsy report is available, often the margin or hormonal status for breast cancer is unknown.
5) Apart from CT and MRI imaging equipment, there are no other imaging systems such as SPECT or PET. There is no functioning nuclear medicine equipment in Cameroon or central Africa. COC is at the point of acquiring a SPECT-CT to implement a nuclear medicine program that would aid diagnosis of distance metastasis.
6) Conflict between the USA and the onsite Cameroon medical teams. Often, the Cameroon radiation oncologist wants the patient to be treated differently than what the US medical team suggests. This has really been a source of headache for the coordinator of the tele-oncology program. We are going to be incorporating weekly new patient conferences and weekly patient review conferences with attendance from both the US and Cameroonian teams to reduce this tension.
7) Knowledge transfer especially for radiation treatment planning is slow since most of the treatment planning takes place in the United States so we are planning to move the treatment planning to be done in Cameroon but supervise from the USA.
8) Reliable power is also a major problem. In the first year of operations, about 35% of our expenses went for power expenses (electricity bills and purchase of fuel when utility power is not available). In the most recent past, expenditure on power is now about 15-18% of our total monthly expenditure. A possible solution is to explore alternative sources of energy such as solar.
9) Reliability and stability of internet. The internet bandwidth paid for is not what is supplied and the internet bandwidth is very unstable. Transmission of large files is not a problem but stability of the network to enable contouring operations from Cameroon for 3D and IMRT-based planning is not at present possible. Though we have a dedicated fibre optic line from the country's main backbone to the center, the reliability and stability is still a major issue. Switching to a different network provider is a potential solution. We have just concluded a feasibility study to use a satellite communication system with a South African company.
10) Other supporting care services for oncology including surgical oncologist, neurosurgery, etc are not currently present. We intend to recruit these professionals in the future once the resources are available.

# 5. Discussion

This paper describes the radiation treatment workflow employing telemedicine at COC. Traditionally, telemedicine has been used to provide medical education or care in rural/remote areas [9, 14]. Recently, its implementation in RT has been rapidly adopted following the outbreak of the COVID-19 pandemic [8, 15–17]. In the present work, we adopted telemedicine in radiation oncology in response to the shortage of resources to provide high-quality radiation treatment to cancer patients at COC. The hybrid tele-radiotherapy system has enabled us to provide high quality care in oncology that would not have been possible despite the challenges as outlined in this manuscript. Equipped with a modern medical linac, CT simulator, TPS, and well-qualified personnel consisting of an onsite and US-based teams both participating in the medical care of cancer patients, COC has all the elements of a modern radiation oncology center. With such a setup and employing telemedicine protocols, COC is able to provide high-quality radiation treatment to cancer patients in the central African sub-region at nominal pricing that some patients can afford. Cancer patients at COC receive RT treatment at a level that is comparable to what a similarly

diagnosed patient would get in a more advanced economy at fraction of the cost they would have paid.

Can the present setup be reproduced by other institutions in SSA? The project promoter is based in the United States and he himself is also a radiation oncology professional with 25 years of professional experience. He has used personal connections to get a team on board that may not be easily reproducible. There is no institutional support from the United States but support comes from individuals who are dedicated to see high quality radiotherapy flourish in other parts of the world. So the project therefore cannot be easily reproducible but some aspects from it can be utilized by other institutions in SSA. We believe that the best way for the radiation oncology centers in SSA to solve the knowledge gab is to find a suitable partner in the US and Europe or South Africa that they can pair with so that knowledge can be transferred.

## 6. Conclusion

The work presented in this manuscript is of value both to our center and other radiotherapy centers in similar situations as COC is able to perform high-quality radiation treatment planning to cancer patients in central Africa to international standards but at nominal pricing using telemedicine protocols. Telemedicine is therefore an effective tool to offer quality assured and safe radiotherapy to cancer patients. The primary benefit of telemedicine in our case is the increased access to well-trained and experienced professionals for safe and effective practice of radiotherapy. It is also cost-effective in terms of hiring or training qualified experts. We intend to improve our telemedicine service in the future by implementing a full video-conference between the US- and Cameroon-based teams, weekly conferences for new and existing patients, and moving part of the treatment planning to Cameroon with an increased internet bandwidth. Presently, COC is Cameroon's only radiotherapy center which houses the nation's lone and functional high-tech medical linac.

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