Urgency and Innovation: Transforming Medical Imaging

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Introduction

In a previous document (The Imaging Gap - A life-threatening shortage of diagnostic imaging), the authors presented a wide-ranging view of the status and state of medical imaging today. It ranged over the absolutely central role modern imaging now occupies; it explored the consequent relentless growth of demand for imaging in the developed world; it discussed where imaging is done in the developed world and the various reasons for imaging referrals and the various routes of those referrals; it discussed various inefficiencies in the systems and suggested some ways those inefficiencies might be ameliorated; it explored the deficits in manpower as well as the deficits in technology provision which besets much of the developed world; and it discussed the very different situation in the developing world.

Lessons and a Way Forward

A key conclusion was that the pressure on hospitals could be alleviated dramatically by enabling imaging to be performed in outside facilities. With digital imaging and universal connections there would be no problems with communication of results or reports. Imaging for hospital outpatients might be so performed externally, a portion of Accident and Emergency (Emergency Room) departments' case pressures could also be alleviated by having patients be referred by Family Practitioners or to self-refer to out-of-hospital facilities which have imaging technology, as well as patients in-need of follow up and many others. A wide range of conditions and presumed conditions could be investigated in this way with, experience suggests, only a small proportion needing ultimately to be sent to hospital. This could revolutionize the way the medical system works, either private or public, with a powerful first-line imaging triage.

Personnel Deficits

Given the increasing demand for imaging, and the constant overload hospitals worldwide are dealing with, it was accepted that manpower problems were unlikely to be overcome by sufficiently large increases in investment in training and employment of radiologists, technicians and support workers. It was reasoned that the role of TeleRadiology, Cloud-based systems and Artificial Intelligence (AI) would come to play an increasingly important part in solving this problem.

Technology Costs

Whether speaking of the developed or the undeveloped world, it is obvious that the principal problem in the provision of imaging equipment is an economic one. Even the simplest of "conventional X ray" equipment is expensive and such modern technologies as CT scanners are very expensive. An important, if obvious, point was made in the document that if high quality and versatile imaging equipment were to be made available at a significantly lower cost than existing equipment this would represent a "game-changing" development.

Range of Medical Imaging

When discussing out-of-hospital imaging, one should consider which procedures are the best candidates for this opportunity, and how all stakeholders can benefit from such a centre. In essence, innovation must accommodate both medical and practical needs. For example, when discussing contrast agent-based imaging, one must consider the fact that these procedures takes a relatively long time and demand the physical presence of medical personnel to monitor the administration of the contrast agent, either IV or orally. Thus, due to the relatively overall low demand for contrast-agent based imaging (which will be discussed later) combined with the special resources that are needed to execute such procedures, these examinations are not the optimal candidates to perform out-of-hospital and to be included in these first-line imaging facilities.

On the other hand, we might consider "conventional X ray" devices, versatile versions of these with horizontal and vertical (lying and standing) configurations, "dynamic" systems, tomographic systems and combined "conventional X ray" and tomographic systems, to be the first candidates to be taken out-of-hospital. This includes a great variety of applications, amongst them the most frequent ones that are in use, those for chest X rays (Lungs) and bone X rays (MSK).

A strategic decision has to be made as to what is the most urgent need of the industry, in order to take an initial position. It would be reasonable to base this decision on criteria involving demand and practicality, as well as supplying clinically significant unmet needs and access to new markets that up to now have lacked powerful imaging for reasons discussed above.

An Exponentially Growing Demand

A central fact about the demand is that in spite of the proliferation of new technologies and demand for highly sophisticated imaging, conventional chest X rays and simple Musculo-Skeletal studies (both conventional X rays and tomography) are still used in very large volume.

Thus, in some snapshots of imaging activity in the UK, cited in WP1 (1, 2, 3), conventional Radiography (X-ray) had the biggest share of all tests, more than 50%, performed during in 2017/2018, 2018/2019 and 2019/2020. See details below. In support of this, in a single, randomly chosen hospital in London conventional X rays constituted almost exactly 50% of all imaging in every year over a 5-year period.
The continuing importance of conventional X rays is thus clear. Their diagnostic power should not be underestimated.

As regards chest X rays:

- **They can diagnose a wide range of lung disease such as: acute pneumonia, bronchiectasis, pneumothorax, lobar collapse, fluid overload, emphysema and lung cancer.**
- **They can give us information about the heart such as enlargement, coronary artery calcification**
- **They can give us information about the aorta such as aneurysm or dissection.**
- **They can diagnose rib and other fractures.**
- **They also allow monitoring of post-operative infections, the position of intravenous lines, endotracheal tubes, etc.**
- **Their value in a pandemic such as the one the world is now experiencing with the COVID-19 is obvious.**

As regards bone conventional X rays in bone and joint/musculo-skeletal conventional film imaging, these can be of great value in making such diagnoses as:

- Diagnosis of fractured bones or joint dislocation.
- Demonstration of proper alignment and stabilization of bony fragments following treatment of a fracture.
- To guide orthopaedic surgery, such as spine repair/fusion, joint replacement and fracture reductions.
- To look for injury, infection (osteomyelitis and joint infections).
- To diagnose both inflammatory and degenerative arthritis.
- To assess abnormal bone growths such as benign and malignant bone tumours.
- To assess bony changes seen in metabolic conditions.
- To locate foreign objects in soft tissues around or in bones.

We therefore see, and it is worth emphasising, the continuing importance of the oldest form of medical imaging, conventional X rays. If the capability of performing tomography is added to its range, its power is further hugely increased.

The Evidence

Since, as explained in our previous paper, the number of medical imaging devices per capita varies significantly across the globe, acquiring reliable statistics concerning this field is a demanding task.
In order to get to a rough estimation of the overall need, we reviewed several reports and articles. In England's National Health Service, for example, imaging activity reports consistently indicate growing imaging demand and a predominance of chest X rays and musculoskeletal imaging.

Thus, in the year up to March 2017 42.1 million imaging tests were reported in England compared with 40.7 million in the previous year, an increase of 3.6%. Conventional Radiography (X-ray) was most common with 22.9 million procedures. CT Scans were 4.82 million and Magnetic Resonance Imaging (MRI) were 3.36 million (1).

In the year to March 2018 42.7 million imaging tests were reported compared with the 42.1 million in the previous year, an increase of 1.4%. Conventional Radiography (X-ray) was most common with 22.9 million procedures, followed by Diagnostic Ultrasonography (Ultrasound, 9.51 million), Computerized Axial Tomography (CT Scan, 5.15 million) and Magnetic Resonance Imaging (MRI, 3.46 million) (2).
And in the year to March 2020 there were 44.5 million imaging tests reported. Of these, 2.73 million imaging tests were reported to have taken place in March 2020. And it should be noted that a great deal of outpatient imaging was reduced because of the impact of the Covid-19 pandemic (3).
This picture has in fact been consistent since the turn of the millennium. In 2001 a report was released by the National Radiological Protection Board examining the medical radiation exposures of UK citizens from medical and dental X ray examinations. The report revealed that about 54% of all procedures were chest X rays and bones, joints and abdomen studies (4).
This picture is found to be reflected on a global scale. In a 2019 report by Frost and Sullivan (5), it was concluded that:

"Conventional radiography (X-ray imaging) today represented approximately 50% of imaging and is a core component of diagnostic imaging. Healthcare providers frequently rely on conventional X-ray studies to aid in the diagnosis, treatment and management of medical conditions in the chest, abdomen and pelvis, extremities, and spine. X-ray is the start of the diagnostic imaging care pathway in terms of how patient care pathways are designed and enables many fundamental aspects of diagnosis."

Growth was predicted in use of X rays and in the numbers of providers.

Another market report (6) concluded that in 2018 the x-ray segment accounted for the largest share of the diagnostic imaging services market and that the key factors driving the growth of this market include the rising geriatric population, lower cost of X-rays as compared to other imaging modalities, favourable returns on investments, and technological advancements in X-ray imaging systems.

Yet another report (7) predicted a growth of the world-wide diagnostic imaging market to grow by US$9.4 Billion, driven by a compounded growth of 5.1%. X-ray Imaging, one of the segments analysed in the study, displays the potential to grow at over 4.8%. It remarked that: "The shifting dynamics supporting this growth makes it critical for businesses in this space to keep abreast of the changing pulse of the market. Poised to reach over US$7.5 Billion by the year 2025, X-ray Imaging will bring in healthy gains adding significant momentum to global growth."

And yet another (8) concluded that global revenues for medical imaging equipment would reach $24.0 billion in 2020. The analysis demonstrated a steady consistent rise of Conventional X ray imaging
These results will not surprise any expert in the medical imaging field: the overall consensus is that x-ray-based devices contribute some 65-70% of the total workload of the imaging world. Of this, conventional X rays account for 50-60%, while CT accounts for 6-10% (dental imaging has been excluded).

Focusing on chest and MSK procedures that do not include the abdomen, we can sum up that supplying X-ray - based conventional and tomographic imaging for chest and MSK, approaches some 70% of all procedures that are done using X-ray-based imaging.

One must remember that this percentage might be misleading, as this need for imaging is ever-growing and additional new markets that inherently need this service specifically for chest or MSK imaging, have very limited accessibility to imaging devices, either due to lack of equipment, accessibility, human (or other) resources, or overload of the system.

To conclude, we emphasise that Chest and MSK procedures (with tomography included) not only cover approximately 70% of all imaging work but, in absolute terms, these numbers are growing yearly, and are expected to grow even more as medical imaging devices are supplied to under-equipped markets and developing countries, supported by cloud technology, enabling affordable and accessible imaging abilities to all.

Practicality

Why not, it might reasonably be asked, begin with brain and body tomography? After all, though not as great as for Plain Films, the demand for these in a great variety of acute and chronic illness situations is also very high.

One obvious response is that, as discussed above, these applications frequently, and with abdominal scanning almost invariably, require contrast enhancement. While medical interpretation of images, medical prescriptions and referrals to hospital for serious findings, can all be done remotely (teleradiology, tele-prescribing and tele-referrals), contrast agents cannot be administered remotely. It is true that non-medical workers can be trained to site an intravenous line and to operate a contrast agent pump, but the availability of medical personnel to manage the (admittedly rare) contrast agent reactions is essential. This does not mean one should not consider these applications to be candidates to out-of-hospital imaging, but to put them second in line for this new and exciting methodology.

Other Imaging Applications?

We might consider other such X ray-based application in imaging as Dental Radiography which does not require the use of contrast agents.
However, Dental Radiography is already being done most of the time at the dentist office, empowering significantly the suggested approach towards out-of-hospital imaging.

Unavoidable Conclusion

Our discussion of demand and practicality appears to strongly indicate that the first step in the progress of development, and the first commercial offers and installations, should be aimed specifically at Plain Film with tomographic capability. The greatest demands in Plain Film imaging are for Chest X rays and Bones and Joints and the advantages of augmenting the diagnostic yield of these studies on occasion by performing tomography is considerable. This should, we conclude, be the first aim to be achieved. This will create a unique win-win-win situation: to the patients, to the service provider/hospitals and to the healthcare system (either private or public).

The Developing World

All the facts and arguments rehearsed above apply equally to the developing world and perhaps more so. Of course, the future demand as nations develop will be for all of the most sophisticated and versatile imaging currently enjoyed by the developed world, but the most important demand currently is clearly for X ray devices which can take chest X rays and X rays of bones and joints. To supply the said needs at more affordable prices would clearly be of great benefit to those parts of the world and, of course, it represents an enormous market. The provision of a basic tomographic facility to be used on occasion would, even if without contrast enhancement, provide other great benefits.

Manpower difficulties, which are obviously far greater than in the developed world, could be solved in the same way as we have discussed: by Tele-radiology, Cloud-based systems and AI.
It might be noted that there are more remote parts of developed nations which in terms of local imaging provision are like the developing world, as they suffer a low number of medical imaging devices, which results in lack of accessibility for their communities. In this regard, the above arguments are relevant for these distant areas and clinics.

Bringing imaging to New Markets and Urgent Clinical Needs

As mentioned in our previous article, there is an inherent overload on medical systems worldwide, which, in turn, reflects lower accessibility to imaging devices for any other medical or para-medical sectors, that are not affiliated directly to hospitals, or that do not define by acute medical situation. Providing these sectors an affordable and accessible imaging system, will change dramatically the level of service that the patient can benefit from. This means not only redefining the current market with its ever-growing demand for imaging, but considering a large imaging underserved medical and paramedical practices. This can be achieved by either stand-alone Imaging Centres to serve these sectors, or in-office imaging device at physiotherapy and Chiropractice Clinics, Orthopaedic and Sports units Clinics, some GP/FP offices, amongst numerous other facilities, as it is these days in the orthodontal world.

They will then be able to offer a fully comprehensive service to the patient/customer without the need to send the patient to another clinic to perform the needed imaging, or just to provide a service without the needed imaging.

Conclusions:
Driving an Imperative for Change

Analysis of both demand and practicality appears to drive us to the conclusion that, whether we are considering the developed or the undeveloped world, the first urgently needed thrust should be a focus on Plain Film radiography with a capability of augmenting this with tomography, focusing on the chest and MSK. This would, if augmented by a tomographic facility, not only cover something approaching 70% of the current market but, in addition, would supply imaging services to presently underserved medical and paramedical sectors, enabling better care for the patient care.

Together with an affordable imaging device and cloud-based technology, this would be revolutionary, both as an advance in radiological technology and as an essential clinical modality.
It would change the way the imaging world is being managed today: reducing dramatically the overload on the medical system as a whole, especially hospitals, improving dramatically the accessibility in under-developed countries to the vast majority of imaging needs, and enabling new sectors worldwide to use imagining as readily as it is today used at the dentist.

However, we would stress that this is the first step in disrupting the 21st century change in the imaging world. Later evolutions should include other anatomical areas. For e.g., the potential benefit to patients and the huge market for tomographic devices capable of high-quality body and head imaging at low cost should not be forgotten and we suggest that this development be not too long delayed.

In this sense, NanoX would appear to be the obvious candidate to revolutionize the medical world. The company is developing a flexible imaging device at significantly lower prices, based on its unique cold cathode technology and business model, coupled with cloud-based telemedicine and AI contribution in the future. This would create a win for all stakeholders of the industry. The Nanox philosophy, first and foremost, is the gain offered to individual patients worldwide; then, more widely, enabling access to imaging in developed and developing countries, reducing the overload of the hospitals, and thereby supporting local health services/suppliers (private or public). The beneficiaries are: individuals, local

communities and the national health systems, whether public systems or private systems/ insurers. Simply put, Nanox can drive innovation and democratization of life-saving technology around the world.

In addition, this can serve as a decisive response to the ever-growing demand for medical imaging, in addition to enabling unequipped clinics and sectors to give the comprehensive care that both patients and clinicians are so eager to achieve.

This will enable a massive change in the medical and para-medical world. It is reasonable to believe that the use of this technology will not only serve out-of-hospital imaging but will be adopted sooner rather than later by major hospitals who wish to augment their imaging capabilities and the spectrum of imaging services they offer their patients.

Supporting references

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