Use of artificial intelligence in chest imaging

Some reflections

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Health and Artificial Intelligence: Law, Ethics and Society
Workshop 1: Ethical Considerations and Policy Development
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The WHO is the UN agency with a specific public health mandate as the directing and coordinating authority of international health work.
Objective: attainment by all peoples of the highest possible level of health.

“Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” (WHO Constitution, 1948)
Health is a human right

The right to health includes access to timely, acceptable, and affordable health care of appropriate quality.

The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being...

WHO Constitution
Universal Health Coverage

- **Universal Health Coverage** (UHC) is a high priority for WHO and its Member States
- UHC includes **safety and quality** of health services
- Ensuring safe and appropriate use of radiation in medicine contributes to achieving UHC

Let's work together towards good health & wellbeing for all.

UHC LEAVES NO ONE BEHIND.

World Health Organization
Health Care Quality Dimensions

- Appropriateness
- Accuracy
- Affordability
- Accountability
- Safety
- Timeliness
- Patient centricity

The safe and appropriate use of radiation for diagnosis and treatment of disease and injuries is embedded in the concept of **health care quality**.
Use of Radiation in Health Care

- Advanced radiation imaging technology has opened new horizons for clinical diagnostics and has improved patient care.

- Benefits for patients gain recognition the use of radiation in the diagnosis and treatment of human diseases increases.

- Inappropriate use and/or unsafe handling may result in unnecessary and preventable radiation risks in patients and staff.
Radiation benefits and risks

- Need to control and minimize radiation health risks, while maximizing the benefits.

- Achieving this balance becomes particularly challenging in medicine.

- The benefit outweighs the risk when the procedure is:
  - appropriately prescribed
  - properly performed
Bonn Call for Action: 10 actions to improve RP in medicine in the decade 2012-2022

1. Enhancing implementation of justification of procedures
2. Enhancing implementation of optimization of protection and safety
3. Strengthening manufacturers’ contribution to radiation safety
4. Strengthening RP education and training of health professionals
5. Shaping & promoting a strategic research agenda for RP in medicine
6. Improving data collection on radiation exposures of patients and workers
7. Improving primary prevention of incidents and adverse events
8. Strengthening radiation safety culture in health care
9. Fostering an improved radiation benefit-risk-dialogue
10. Strengthening the implementation of safety requirements (BSS) globally

http://www.who.int/ionizing_radiation/about/med_exposure/en

These priority actions continue being essential during the response to the pandemic and in the post-COVID-19 time
COVID-19, WHO response
About Rene Francois Magritte (1898-1967)

- Internationally acclaimed surrealist artist well known for creating thought-provoking images, often depicting ordinary objects in an unusual context. By using simple graphics and everyday objects he gave new meanings to familiar things.

- In his self-portrait «The clairvoyance» (1936) Magritte is looking at an egg and painting a bird, which is more than what is right in front of him: he is painting the possibility, potential, the future.
About Dr. Victor Tseng

- Young pulmonary and critical care physician from USA with interest/expertise in chronic respiratory failure, mechanical ventilation, unexplained dyspnea, exercise physiology, high altitude medicine, pulmonary hypertension, pulmonary complications of liver disease, and interstitial lung diseases.

Also involved with teaching of residents and medical students; doing clinical research; member of a number of professional societies. In his free time he enjoys alpinism, traveling, music composition, ski racing, and playing the piano and violin in chamber ensembles…

What do painter and physician have in common?
In March 2020 Dr Tseng’s tweet about the future

As our friends and colleagues brave the front lines, we must also get ready for a series of aftershocks. It's very hard to plan this far ahead while we're in survival mode. We must prepare early and strategize our response to the collateral damage of #COVID19
Mantaining essential health services

- In the early phases of the COVID-19 outbreak, health systems could maintain service delivery in addition to managing a relatively limited COVID-19 case-load.

- As COVID-19 demands on systems have surged and health workers themselves have increasingly been affected by COVID-19 infection and indirect consequences of the pandemic, strategic adaptations have become urgent to balance the demands of responding directly to the COVID-19 pandemic with the need to maintain the delivery of other essential health services.

% of countries reporting disruption in NCD and mental health services

SOURCE: WHO pulse survey on continuity of essential health services during the COVID-19 pandemic, Aug 2020

Reasons for service disruption

- Decrease in outpatient volume owing to patients not presenting: 76%
- Decrease in inpatient volume owing to cancellation of elective care: 66%
- Related clinical staff deployed to provide COVID-19 relief: 49%
- Government or public transport lockdowns hindering access: 48%
- Insufficient personal protective equipment available for health care providers: 44%
- Closure of population-level screening programmes: 41%
- Closure of outpatient disease-specific consultation clinics: 35%
- Changes in treatment policies: 33%
- Financial difficulties during outbreak/lockdown: 33%
- Closure of outpatient services by government directive: 33%
- Unavailability/stock out of health products at health facilities: 30%
- Insufficient staff to provide services: 29%
- Others: 27%
- Inpatient services/hospital beds not available: 9%
COVID-19, WHO response and chest imaging

Since the beginning of the outbreak, an increasing number of papers reported the use of chest imaging.
WHO developed guidance on use of chest imaging in COVID-19
Published in English, translated into 7 other languages: Arabic, Chinese, French, Japanese, Portuguese, Russian and Spanish
Use of Chest Imaging in COVID-19: scenarios considered

- Asymptomatic patients
- Symptomatic patients with available RT-PCR testing
- Symptomatic patients with no RT-PCR available
- Admitting or discharging patients with mild symptoms
- Patients with moderate-to-severe symptoms
- Therapeutic management of hospitalized patients
- Discharging hospitalized patients

NEW: updated literature reviews, qualitative study on contextual factors and consider use of chest imaging after hospital discharge
Summary of WHO guidance (I)

- Chest imaging used in diagnostic workup and management of patients with COVID-19
- Chest imaging as one element of the patient evaluation that otherwise includes clinical and laboratory data.
- Chest imaging not suggested:
  - to diagnose COVID-19 in asymptomatic patients
  - to diagnose COVID-19 in symptomatic patients when RT-PCR testing is available and timely
  - to help inform discharge decisions for hospitalized patients whose symptoms have resolved
Chest imaging is suggested to diagnose COVID-19 in symptomatic patients:
- when RT-PCR testing is not available
- has delayed results
- when an initial RT-PCR test is negative, but there is high clinical suspicion of COVID-19

Chest imaging is also suggested:
- for decision to admit or discharge patients with mild symptoms
- for decision about normal ward or ICU (moderate-to-severe symptoms)
- to help inform the therapeutic management of hospitalized patients with moderate-to-severe symptoms.

Guideline ID: 1826       Published: 2020 Jun 11

World Health Organization (WHO)

Priority medical devices list for the COVID-19 response and associated technical specifications

20 November 2020 | COVID-19: Essential resource planning

Overview

This document describes the medical devices required for the clinical management of COVID-19, selected and prioritized according to the latest available evidence and guidelines. This includes: oxygen therapy, pulse oximeters, patient monitors, infusion and suction pumps, X-ray, ultrasound, and CT scanners as well as personal protective equipment. In order to facilitate access to quality assured priority devices, the document also includes technical and performance characteristics, standards, accessories and consumables. It is intended for policy-makers and technical officers in Ministries of Health, procurement and regulatory agencies, international organizations as well as the medical device industry.

This document is an update to the List of priority medical devices for COVID-19 management and Technical specifications for invasive and non-invasive ventilators for COVID-19.

This document complements the Technical specifications of personal protective equipment for COVID-19.

In June 2020, WHO published a rapid advice guide on the use of medical imaging in the context of the COVID-19 pandemic. The guide makes recommendations for the use of chest imaging in the acute care of adult patients with suspected, probable or confirmed COVID-19, based on available evidence. The imaging modalities considered are ultrasound, radiography and computed tomography (CT), for use within the care pathway.

In view of the urgency to produce a complementary document of technical specifications of equipment to support the rapid advice guide, a working group was established with staff and consultants on imaging technologies from WHO and the International Atomic Energy Agency (IAEA). The draft was sent to experts and nongovernmental organizations for review and comment.
WHO Academy learning app

WHO free app available in seven languages – Arabic, Chinese, English, French, Portuguese, Russian and Spanish - in the Apple App Store and the Google Play Store

3 modules on chest imaging coming soon

www.academy.who.int
Typical COVID-19 imaging findings

Chest imaging useful in diagnostic work-up and management of patients with suspected or confirmed COVID-19, in association with history of exposure, clinical and laboratory data. Typical imaging findings:

- Interstitial thickening, ground-glass opacities and consolidation zones in chest radiography and chest CT.
- Irregular borders of the pleural line, confluent hyperechoic vertical lines (so-called B-lines), interstitial
- Bilateral, multiple, with peripheral and posterior localization, usually with basal predominance.
Images courtesy of:
Chiara Beatrice Cogliati, MD, Director of Unità Operativa di Medicina Interna a Indirizzo Fisiopatologico, Ospedale Luigi Sacco, Università degli Studi di Milano
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Artificial intelligence in COVID-19

The COVID-19 outbreak motivated a large scale clinical and imaging data collection to generate evidence to inform decision-making.

Innovative solutions were proposed to fight against COVID-19 pandemic using artificial intelligence for:

- Tracking and predicting how COVID-19 would spread over time and space;
- Identifying possible treatments and vaccines;
- Supporting social distancing (e.g. infrared thermal scanning, enforcing social lockdown measures);
- Diagnosis and prognosis of the disease (e.g. chest radiography, CT scans and lung ultrasound).
AI in chest imaging in COVID-19

- Visual interpretation of chest images by radiologists at a larger scale is time-consuming and require prior knowledge about the typical imaging findings of the disease.

- Automated methods using Artificial Intelligence (AI) technologies, mostly Deep Learning (DL) algorithms have been developed to enhance the power of chest imaging and reduce the workload of radiologists.
Deep learning (DL) in chest imaging

DL utilizes **algorithms** composed of artificial neurons and multiple data processing layers in an architecture referred to as a Deep Neural Network (DNN), including a subtype called Convolutional Neural Networks (CNNs).

The algorithms can make **data-driven predictions or decisions** by building a mathematical model based on **input data**, which usually comes from three datasets: **training dataset**, **validation dataset** and **final test dataset**.

The **data of interest** is **input** to the network along with its **ground truth label** e.g. the pixel data of a chest x-ray along with the diagnosis “COVID-19 pneumonia”
DL for chest imaging in COVID-19

- **DL models** for detection of COVID-19 associated patterns have been mostly used in chest x-rays and chest CT scans, and their use was also reported in lung ultrasound.
  - **Diagnostic performance** of the AI systems comparable to that of practicing radiologists with significant clinical experience and could assist and improve the performance of junior radiologists.
  - Need for large **imaging datasets** with solid ground truth.
  - Transfer learning strategies used at early stages, AI algorithms integrating chest imaging findings with clinical symptoms or exposure history, initiatives to publicly disseminate imaging dataset (e.g. RSNA open database), research projects (e.g. NIH MIDRC).
Assessing literature about AI in chest imaging for COVID-19: some caveats

- It is difficult to conduct systematic reviews of the literature about use of AI in chest imaging for COVID-19:
  - Many studies evaluate images from databanks, limited clinical information (except having the condition or not) and even those using “clinical” data set reporting limited clinical characteristics. Studies typically use a case-control design (bias issues).
  - The reporting of the AI algorithms is often suboptimal, there are many and there is often lack of independent validation.
  - Frequently the AI algorithms are not available for clinical use and/or it is unclear if they are freely available.
  - AI regulation varies across countries- where AI is treated like a “medical device” there is some kind of review/approval process, not much information on what is being done in other countries
Ethical and legal implications of AI

The EU General Data Protection Regulation (GDPR) entered into force in 2018 unified the provisions on the processing of personal data (i.e. all information concerning a person who can be identified directly or indirectly).

– In response to the COVID-19 pandemic, the European GDPR allows personal data collection and analysis, as long as it has a clear and specific public health goal.

– While prompt gathering and analysis of big data is essential in fighting pandemic, many people might feel uncomfortable if the authorities collect personal data.

– This has implications for AI and it is crucial that all the involved actors handling such data carefully (ethical and legal issues).
Need for a balanced approach

There is an unprecedented opportunity to leverage AI for societal benefit - its efficacy will depend on:

- Reliability and relevance of the data available, robust testing and verification of AI systems.
- Effective strategies for delivery and implementation.
- Balance between the potential of AI to do more good than harm (i.e. beneficence/ non-maleficence) against confidentiality, data ownership, health inequities, fairness and others (i.e. dignity and justice). Ethical considerations as part of the process of developing new AI applications (i.e. think ahead, “ethics by design”).
Computer science plus delivering science

Developing a delivery science for artificial intelligence in healthcare

Ron C. Li, Steven M. Asch, and Nigam H. Shah

Artificial Intelligence (AI) has generated a large amount of excitement in healthcare, mostly driven by the emergence of increasingly accurate machine learning models. However, the promise of AI delivering scalable and sustained value for patient care in the real world setting has yet to be realized. In order to safely and effectively bring AI into use in healthcare, there needs to be a concerted effort around not just the creation, but also the delivery of AI. This AI “delivery science” will require a broader set of tools such as design thinking, process improvement, and implementation science, as well as a broader definition of what practice, which includes not just machine learning models and their predictions, but also the new systems for how they enable. The careful design, implementation, and evaluation of these AI enabled systems will be important in understand how AI can improve healthcare.

npj Digital Medicine (2020) 3:107; https://doi.org/10.1038/s41746-020-00318-y
Creating, implementing and evaluating an AI enabled system for healthcare: 1) user experience design, 2) data science, 3) healthcare operations, 4) clinical informatics, 5) evaluation, and 6) ethical integrity.
Deploying AI solutions

- Limitations in local equipment and infrastructure (imaging equipment, hardware capacity, internet connectivity, electrical instability), radiology workforce (radiologists, radiographers and medical physicists), personnel expertise, data-rights frameworks and public policies difficult the participation in AI production and validation in LMICs.

- An integrated strategy for AI adoption in resource-poor institutions to address health care disparities has been proposed, including 3 components:
  1. clinical radiology education;
  2. infrastructure implementation, and
  3. phased AI introduction.

Mollura D. et al Radiology 2020; 00:1–8 • https://doi.org/10.1148/radiol.2020201434
AI in chest imaging - the way forward

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Many thanks !!!

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