Large Scale Artificial Intelligence Deployment in the Emergency & Radiology Departments in 17 Hospitals in a City for the Detection, Triage & Management of Patients with Acute Intracranial Hemorrhage

NR Mahboobani [1], KWS Ko [1], KK Chan [1], CK Lam [3], CK Lee [3], CW Chau [2], WL Poon [1]

[1] Department of Diagnostic & Interventional Radiology, Queen Elizabeth Hospital, Hong Kong SAR
[2] Accident & Emergency Department, Queen Elizabeth Hospital, Hong Kong SAR
[3] Information Technology Department, Kowloon Central Cluster, Hong Kong SAR

伊利沙伯醫院
QUEEN ELIZABETH HOSPITAL

RSNA® 2024
Building Intelligent Connections
Annual Meeting: Dec. 1–5

醫院管理局
HOSPITAL AUTHORITY

Validation Study

- 811 consecutive non-contrast CT brain scans of adult patients previously acquired in a tertiary hospital in Hong Kong SAR
- Each scan reviewed by 2 radiologists (10 & 6 years of experience) to establish ground truth before sending to vendor AI server

Number of intracranial hemorrhage (ICH) / Prevalence	111 / 13.7%
Epidural hemorrhage (EDH)	3
Intraparenchymal hemorrhage (IPH)	22
Intraventricular hemorrhage (IVH)	4
Subarachnoid hemorrhage (SAH)	13
Subdural hemorrhage (SDH)	44
Multiple types of hemorrhage	25

Vendor AI Results

	ICH +ve	ICH -ve	Total
AI +ve	108 (TP)	23 (FP)	131
AI -ve	3 (FN)	677 (TN)	680
Total	111	700	811

Accuracy	96.8%	95% CI [95.3, 97.9]
Sensitivity	97.3%	95% CI [92.3, 99.4]
Specificity	96.7%	95% CI [95.1, 97.9]
Positive Predictive Value	82.4%	95% CI [75.8, 87.5]
Negative Predictive Value	99.6%	95% CI [98.6, 99.9]

Infrastructure

Hospital intranet

AI augmented workflow

AI vendor server

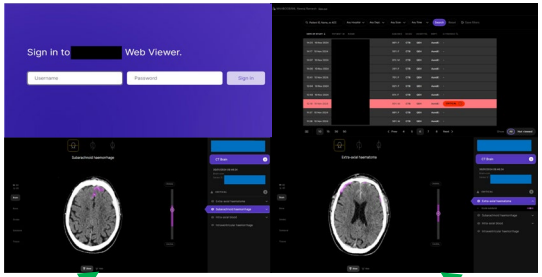
On-premise server

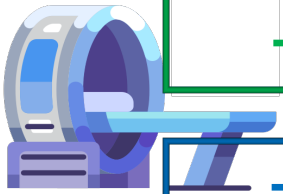
Automated transfer of CT brain DICOM images

CT brain analyzed for ICH by AI software; < 1 minute per CT brain

AI results viewed on vendor web viewer

Vendor AI web viewer portal





CT scanner

DICOM images sent to PACS / Imaging archive servers

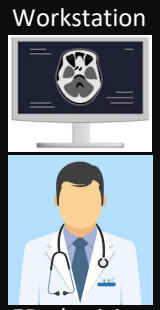
PACS / Imaging archive server

Clinicians view scans on Clinical Management System (CMS) or Radiology (RIS) / PACS workstations

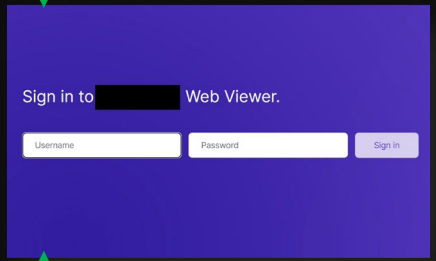
Clinicians view AI results on same workstations

Original workflow

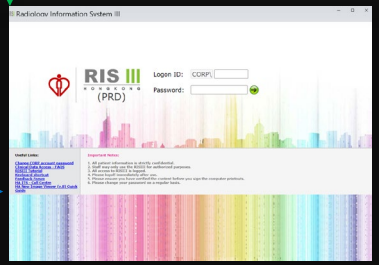
Workstations



Hospital Clinical Management System (CMS)



Vendor AI web viewer portal



Hospital Radiology Information System (RIS) / PACS

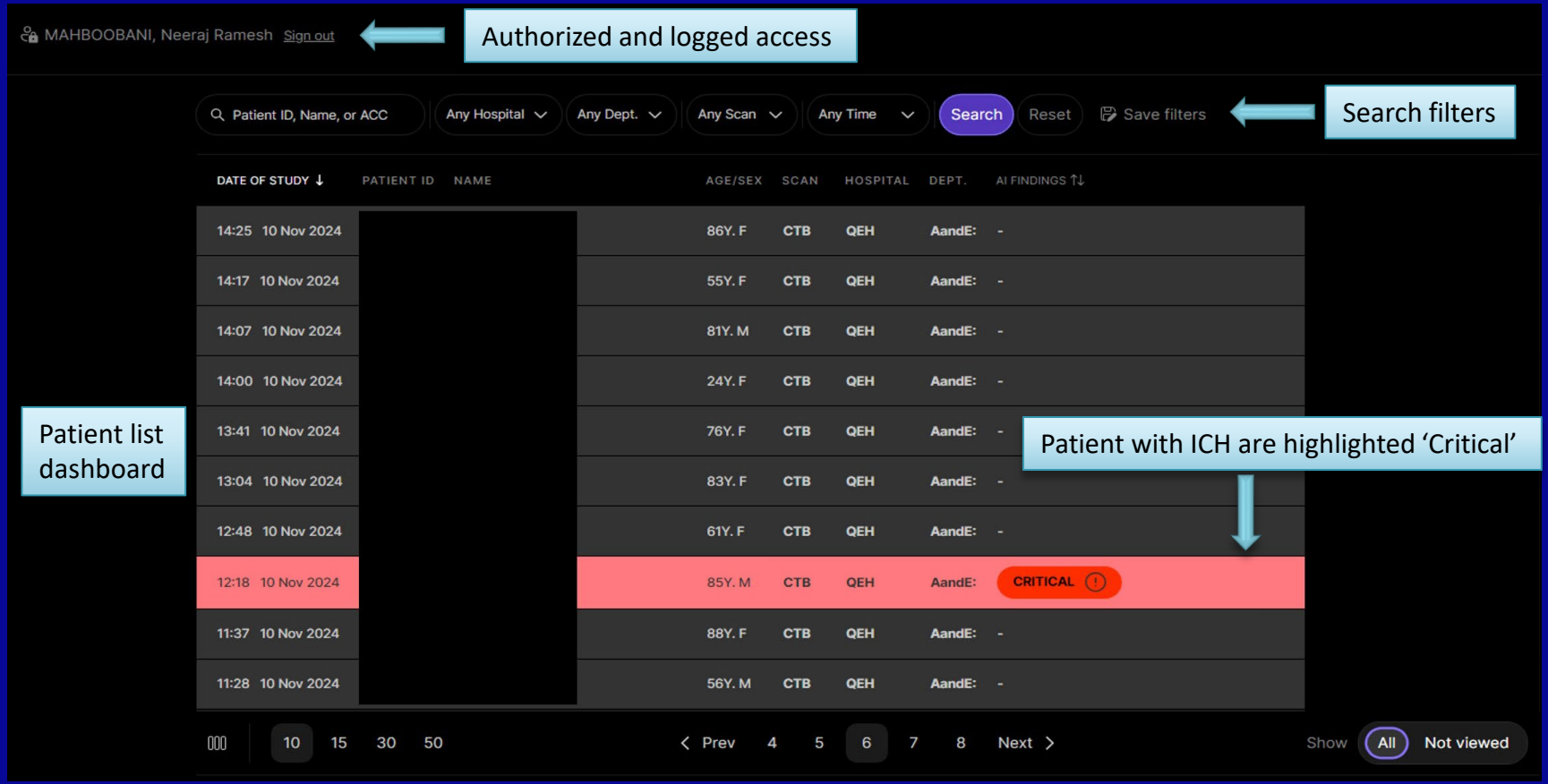
Data security

- AI results are viewed on vendor AI web viewer portal via an access control web browser on authorized workstations within the hospital intranet
- Encrypted data transfer between vendor AI server and client workstations using Secure Sockets Layer (SSL) certificate & Hypertext Transfer Protocol Secure (HTTPS)
- Authorized workstations include all Emergency Department (ED) CMS workstations and all Radiology RIS / PACS workstations
- Addition or deletion of authorized workstations managed centrally by IT department using workstations IP address / machine name

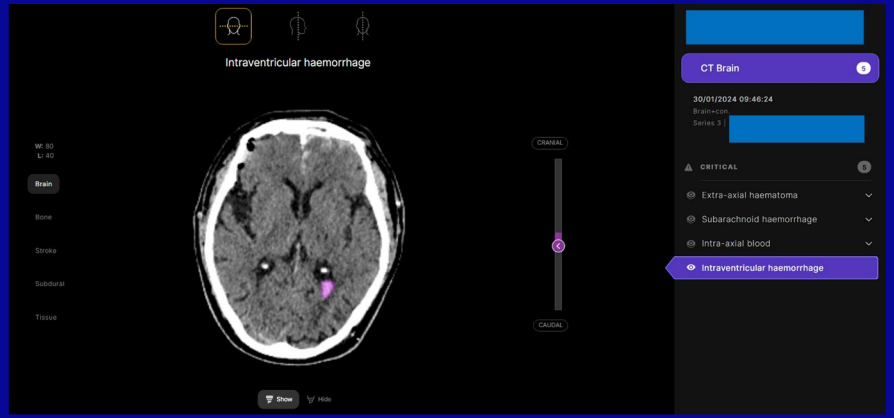
User access

- Authorized users have their hospital user credentials (login ID and password) mapped to vendor AI web viewer portal login using Active Directory (AD)
- Users can therefore access the AI web viewer portal using their personal hospital user credentials
- Change of password on hospital platforms results in change of password for AI web viewer portal as well
- This facilitates adoption by users as they need not remember multiple usernames and passwords
- Ease of adding or removing users by IT department with use of AD when authorized doctors join or leave the hospital workforce

Web viewer portal - Patient list



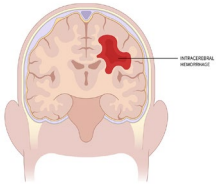
Web viewer portal - Individual patient



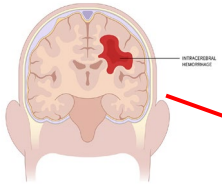
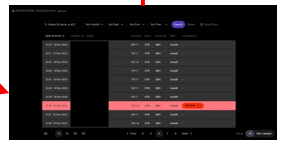
A patient with multiple types of ICH

A patient with SDH in axial and coronal views

Patient journey after CT scan

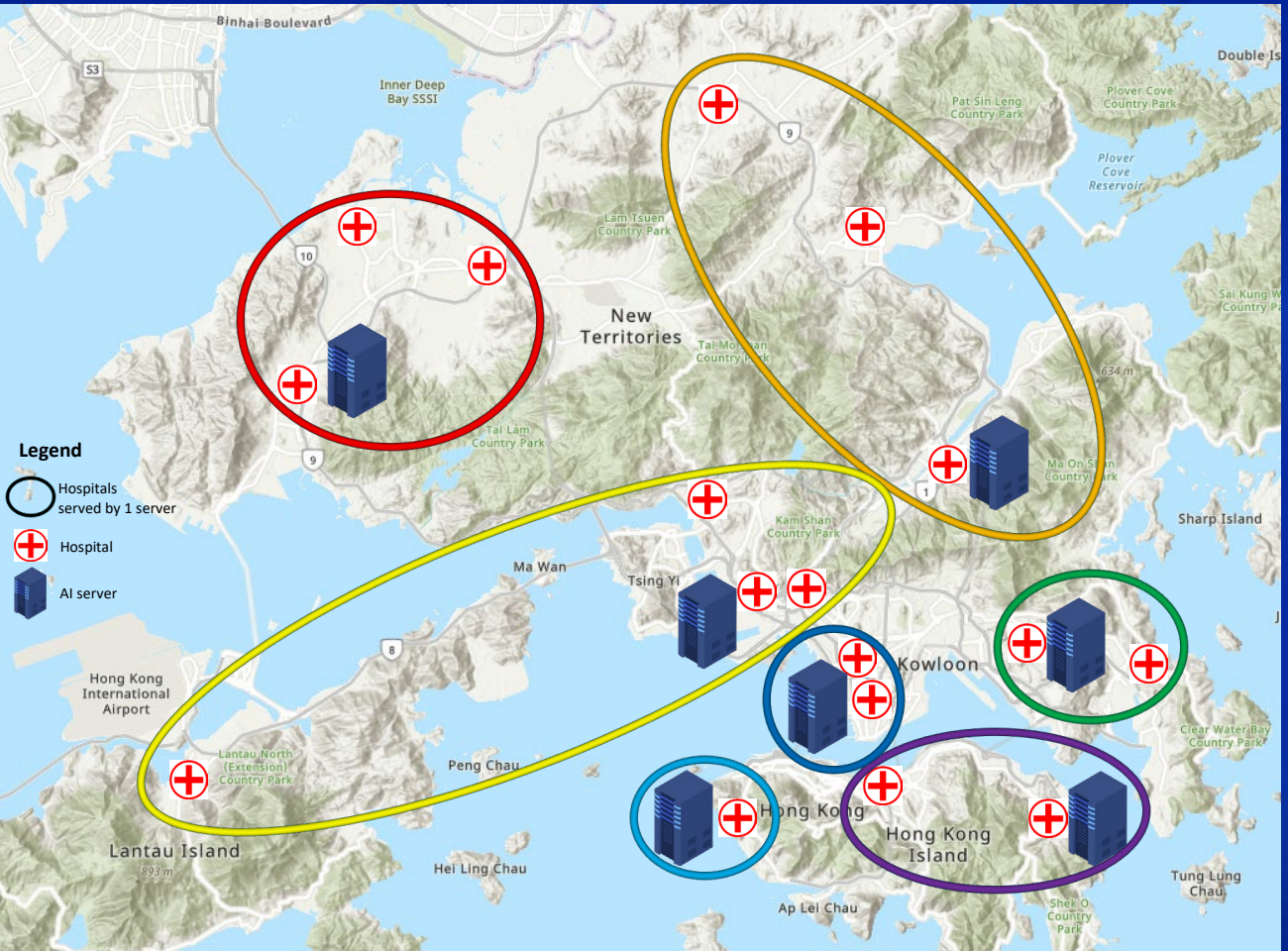
Scan sequence	Conscious patient with neurological symptoms	Patient review sequence by Emergency physician after scan
1		1
2		2 
3		3 
4		4

Patient journey with original workflow

Scan sequence	Conscious patient with neurological symptoms	Patient review sequence by Emergency physician after scan
1		2 
2		3 
3		1  Patient with ICH highlighted on patient list dashboard on workstation / triage station
4		4

Patient journey with AI augmented workflow

Infrastructure across the city



Server Group	number	Annual ED CT brain volume
New Territories East	3	44,400
New Territories West	3	32,800
Kowloon Central	2	24,200
Kowloon East	2	17,000
Kowloon West	4	23,100
Hong Kong East	2	14,700
Hong Kong West	1	12,500
7 servers	**17**	**168,700**
~ 1,000 users	**~ 1,200 workstations**	

Conclusions

- City wide implementation of an AI augmented clinical workflow for the detection, triage and management of patients with ICH after validation of AI software accuracy with own dataset
- Seamless implementation on hospital intranet with an automated workflow requiring authenticated access to view results on authorized workstations
- Can expedite management of conscious patients with ICH waiting to be reviewed in ED after CT brain performed via alert on patient list dashboard
- An ‘assistant’ to ED physicians and radiologists, increasing their confidence and reducing their ‘stress’ in detecting ICH, in particular for junior doctors, especially in patients with subtle ICH or at times of constrained manpower and fatigue during overnight shifts