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- Original Article
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- Initiative / Innovation
- Perspectives
- ASEAN Movement in Radiology

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# The ASEAN Journal of Radiology

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From The Editor

# Continental ASEAN: The complex geopolitical landscapes requiring cross-border cooperation

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Trilateral cooperation between China, Thailand and Myanmar against transnational crimes was witnessed starting from February [3]. Thailand limited electricity, fuel, and internet access at five Myanmar sites which were confirmed to centers of cybercrimes. The central Myanmar government limited fuel to these sites, implemented stricter border management to hinder scam operators from fleeing Myanmar, and transferred the victims, primarily Chinese, to Thailand. This complex operation required reinforcing partnerships while adhering to the respective sovereignties and legal frameworks of the nations. Deeper cooperation strategies and a potential expansion to include other willing nations to combat such illegal transnational enterprises are being further developed. On a larger scale, an urgent and strategic response to the burgeoning illicit economy in Myanmar, dominated by drug trade, human trafficking, and scam operations will be discussed in the ASEAN communities. Scam attempts in 2024 in Thailand alone included 168 million fraudulent calls and SMS messages with deceptive links focusing on gambling and money loan schemes, delivery and utility services, and exploiting government policies such as electricity bill reductions and digital wallet initiatives to deceive people [4] with financial losses suffered by victims in Thailand reaching approximately 80 billion Thai Baht [5].

Coinciding with the 50th anniversary of diplomatic ties between Thailand and China, comprehensive knowledge and proven methodologies, focusing on pollution monitoring enhancement and ambitious reduction strategies that have already transformed Beijing's skyline from grey to clear, will be transferred to Bangkok. This collaboration will embrace a holistic approach integrating practical exchanges, training, and pilot project implementations in Bangkok [6].

During January to March, there were at least eight students from elementary and secondary schools in Buriram province in Northeastern Thailand were hospitalized due to severe respiratory inflammation and were found to have been using e-cigarettes for about two years. One of them died and one was intubated because of severe lung damage [7]. The government intensified its stance on e-cigarettes, with individuals caught with these illegal items facing up to five years in prison and substantial fines. Facing substantial penalties, those involved in selling, buying, importing, or using e-cigarettes risk severe repercussions. The Ministry of Digital Economy and Society blocked over 9,500 URLs related to vape sales. Using advanced social listening tools, the ministry removed numerous online ads, reinforcing a zero-tolerance policy [8].



*The executive committee members and lecturers from the Royal College of Radiologists and the Radiological Society of Thailand participated the 23rd Asia Oceania Congress of Radiology (AOCR) on 23-26 January 2025, Chennai, India; held the 29th RCRT-61st RST Annual Scientific Meeting on 20-22 March 2025, Bangkok, Thailand; and joined the 74th Taiwan Radiological Congress (TRC) on 3-4 May 2025, Taipei, Taiwan.*

On Friday 28 March, just a week after the 29th RCRT and the 61st Annual Scientific Meeting, a massive earthquake originating from Mandalay, where it killed more than 3,700 people and caused major damage, shook Myanmar and Thailand, mainly the northern and central parts. The SMS-based earthquake warning system failed to alert citizens promptly even though it was estimated that the tremors in Bangkok happened around 10 minutes after the epicenter. No injuries or fatalities were reported in Northern Thailand. In central Thailand, the new State Audit Office (SAO) building in Bangkok collapsed. At the time of the quake, 109 workers were present; 89 bodies have since been recovered, with seven still missing. Nine individuals sustained injuries, while four workers who were absent on the day the disaster struck had since returned home safely. Other buildings, including all bridges and underpasses reported cracks and peeling plaster, though their structural integrity remains intact. The collapsed SAO building set grim world records: the tallest building to fall in an earthquake and the furthest from an epicenter to suffer such a fate. It also showcased the vulnerability of Thailand's infrastructure. Despite laws requiring seismic-resistant designs for tall buildings, the collapse suggested serious enforcement issues. Thai media highlighted the role of Italian-Thai's Chinese joint venture partner, the China Railway No. 10 company, which is involved in projects around the world. Evidence and testimony from experts suggested the building plan did not meet standards and codes. The police charged 17 Thai and Chinese companies' directors, contractors, nominees, engineers and architects with the felony of professional negligence causing death [9].

Between 4 and 10 May, Covid-19 cases were roughly double the number of influenza cases, rising from 14,680 to be 16,607 cases, with 6 deaths [10]. Despite their increased transmissibility, these strains seemingly caused mild symptoms and are treatable like other respiratory illnesses. However, the spike in cases and fatalities called for a vigilant public health response as medical experts closely monitor the trajectory of the virus.

Thailand reported 4 anthrax cases in Mukdahan, a province in the northeastern part of the country, and experienced its first anthrax-related death since 1994 on 30 April [11]. Thailand last reported 15 human anthrax cases in 2000 and two cases in 2017, without any death. The cases were from Don Tan, a district in Mukdahan located just across the Mekong River from Laos where 129 anthrax infections, including one related death, were reported last year. Laos's outbreak in 2024 and Vietnam's 13 cases reported in May 2023 underscored the porous nature of zoonotic disease transmission across the region [12].

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Original Article

# Effect of hepatocellular carcinoma conspicuity on ultrasound on the treatment outcome of percutaneous tumor ablation

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## Abstract

**Background:** Percutaneous tumor ablation is a minimally invasive treatment for early-stage hepatocellular carcinoma (HCC) and relies on real-time ultrasonographic guidance. However, it might not be feasible in some patients due to limitations of grey-scale ultrasound findings.

**Objective:** To evaluate the effect of ultrasound conspicuity of HCC nodules on the success rate of percutaneous image-guided ablation.

**Materials and Methods:** A single-center retrospective review of patients undergoing percutaneous tumor ablation of treatment-naïve HCC from January 2017 to December 2022 was performed. Three groups of tumors were classified based on the level of ultrasound visualization as complete visibility (399 lesions), partial visibility (219 lesions) and invisibility (88 lesions). Ablation procedure was performed under ultrasound guidance, supplemented with other modalities such as non-contrast CT and fusion ultrasound. Follow-up assessments were conducted at 1, 3, and 24 months post-ablation to compare the technical success rates. Other outcomes including survival analysis and complications were also investigated.

**Results:** A total of 447 patients with 706 lesions were included. The mean size of lesions in the three groups were 1.84, 1.59, and 1.11 cm, respectively, with statistically significant difference between the groups ($p<0.001$). There was no statistically significant difference in technical success rates at 1 month or primary efficacy at 3 months among the three groups. The technical success rate between the complete visibility, partial visibility, and invisible groups were 95.7%, 95.0%, and 97.7% ($p=0.862$), respectively and primary efficacy rates were 95.2%, 95.0%, 84.1% ($p=0.172$), respectively. The cumulative local tumor progression-free survival at 6, 12, 24 months were 98.0%, 96.9%, and 90.5% for the complete visibility group, 98.9%, 97.9%, and 87.8% for the partial visibility group, and 96.2%, 94.5%, and 87.3% for the invisible group, respectively, with no statistically significant differences ($p = 0.539$). Only one patient experienced a complication that required further treatment.

**Conclusion:** The usage of other imaging modalities such as non-contrast CT and fusion ultrasound for poorly conspicuous HCC lesions can improve the success rates to levels comparable with those of the conspicuous nodules, while also maintaining similar local tumor control outcomes and avoiding major adverse events.

**Keywords:** Fusion ultrasound, Hepatocellular carcinoma, Microwave ablation, Radiofrequency ablation, Tumor ablation.

## Introduction

Hepatocellular carcinoma (HCC) is one of the most prevalent cancers worldwide and is also one of the leading causes of cancer-related deaths in Thailand [1]. Early detection of HCC is aided by the implementation of screening abdominal ultrasound protocols. A definitive diagnosis of HCC can then be confirmed with cross-sectional imaging such as contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI) with hepatocyte-specific contrast agents. A widely adopted staging system for HCC is the Barcelona Clinic Liver Cancer (BCLC) staging system, which details optimal treatment strategies for each stage of hepatocellular carcinoma [2]. According to the latest iteration of the BCLC staging, patients in very early to early stage HCC may be treated with surgery or image-guided percutaneous tumor ablation [2].

Image-guided percutaneous tumor ablation is a well-established treatment for very early to early stage HCC where an ablation needle is percutaneously punctured into the liver and directed toward to the target lesion under the guidance of various imaging modalities. The lesion is then destroyed either chemically, via extreme temperatures, or irreversible electroporation. The vast majority of percutaneous tumor ablation procedures are performed under ultrasonographic guidance, which allows real-time visualization of the ablation probe in relation to the target lesion as well as surrounding critical structures in order to achieve technical success and avoid complications.

However, the inherent limitations of ultrasonography also have an effect on the ablation procedure. For one, visualization of hepatic dome lesions is limited on ultrasound due to obscuration by the air artifact from the lung. The patients with cirrhotic livers show heterogeneous liver parenchyma echogenicity on ultrasound which may obscure the conspicuity of some lesions [3]. All of these effects may lead to mistargeting of the tumor nodule on ultrasound, resulting in insufficient coverage of the ablation zone margins or treatment failure altogether [4-6]. Many techniques have been devised to overcome the limitations of using ultrasound-only guidance in percutaneous ablation. Such techniques include the use of non-contrast-enhanced CT scans to confirm the ablation probe tip in relation to surrounding anatomical landmarks, employing ultrasonography with the aid of fusion software techniques using pre-operative cross sectional imaging (either CT or MRI) [7, 8], or the use of contrast-enhanced ultrasound in which a contrast agent (eg. sulphur hexaflouride microbubbles or perfluorobutane-based US contrast agent), is injected intravenously to allow distinction between hepatic parenchyma and the target lesion [9].

Thus, this study aims to investigate the effect of sonographic conspicuity of HCC lesions on the success rate of image-guided percutaneous tumor ablation, as well as evaluate the short-term recurrent rate and the safety profile.

## Materials and methods

**Study Population**

This study is a single-center retrospective cohort study, with data obtained via retrospective review of electronic medical records of patients who underwent percutaneous tumor ablation from January 2017 to December 2022, referred to the Siriraj Center of Interventional Radiology (SiCIR) by gastroenterologists or hepatobiliary surgeons in accordance with BCLC guidelines. Patients included in this study were (1) at least 18 years of age (2) diagnosed with primary hepatocellular carcinoma either by tissue pathology or from imaging specifically contrast-enhanced CT scan or MRI with hepatocyte-specific contrast agent, classified as either LI-RADS 4 or 5 according to LI-RADS version 2018 [10] (3) underwent either percutaneous radiofrequency ablation (RFA) or microwave ablation (MWA) (4) had preoperative CT or MRI within 60 days prior to ablation (5) and had follow-up CT or MRI scans within 6 weeks following the ablation session and at least 6 months thereafter. Patients were excluded from the study if they (1) were diagnosed with other hepatic lesions such as liver metastases or (2) had insufficient follow-up imaging. Lesions were excluded from the study if it had undergone prior treatment, such as transarterial chemoembolization (TACE) or represented residual tumor following prior ablation sessions; only treatment-naïve nodules were included for analysis. Institutional ethics review board approval (No. Si 019/2024) was obtained prior to data collection. Other information such as the patient's gender, age at time of treatment, liver disease etiology, Child Pugh score, prior history of treatment for HCC, modality of diagnosis, lesion size, location, and proximity to liver capsule or other critical structures, was also recorded.

**Percutaneous Tumor Ablation**

All cases of image-guided tumor ablation were performed under ultrasound guidance by 7 board-certified interventional radiologists. The choice of ablation system was made at the operator's discretion; general rule of thumb at the institution is a predilection towards RFA due to the expandable tines allowing secure placement of the needle while stepping out during each CT scan, but microwave ablation systems would be preferred in cases where the target lesions are in close proximity to vessels and thus prone to the heatsink effect. However, lesion conspicuity or performing intraprocedural NCCT did not necessarily preclude the usage of MWA systems. Patients underwent either sedation or general anesthesia administered by the anesthesiologist. Ablation systems used in this study included RF3000 RFA generator with LeVeen expandable RFA electrodes (Boston Scientific, Massachusetts, USA), Emprint Microwave Ablation System (Medtronic, Minnesota, USA), Saberwave ECO microwave ablation system (ECO Medical Technology, Nanjing, PRC), and MaxBlate microwave ablation generator (Canyon Medical, Nanjing, PRC). The aim of the ablation procedure was to achieve at least a 0.5 cm margin surrounding the target lesion in every case.

Retrospective review of images in the hospital's Picture Archiving and Communication System (PACS) was done to determine the conspicuity of the target lesion and categorized as completely visible, partially visible, or invisible on ultrasound. Lesions were deemed completely visible if all margins of the lesion could be clearly visualized on ultrasound (Figure 1); if any margin was not clearly distinguishable, the lesion would be classified as partially visible (Figure 2). Lesions that were not at all visible on ultrasound were deemed invisible (Figure 3). Echogenicity of the lesion was also recorded as hypoechoic, hyperechoic, or isoechoic relative to liver parenchyma. If a lesion demonstrated mixed echogenicity, it was recorded as heterogeneous echogenicity. Lesion size was recorded based on the ultrasound image obtained on the day of the ablation procedure if the lesion was visible, otherwise the size was recorded according to the most recent CT or MRI findings prior to ablation. For each ablation procedure, the use of other modalities in conjunction with ultrasonography such as non-contrast CT or fusion ultrasonography was collected. Non-contrast CT was performed to compare the relative position of the ablation needle tip with surrounding anatomical landmarks and correlated with preprocedural cross-sectional imaging (Figure 2F). Fusion ultrasound was performed using Logiq E9 and Logiq E10 ultrasound machines (GE HealthCare Technologies, Illinois, USA) ulitizing volume navigation (V-nav) software with the most recent preprocedural CT or MRI scan was used for fusion (Figure 3D-E). Immediate post-procedural complications were also recorded in accordance with the Society of Interventional Radiology Adverse Events Classification System.

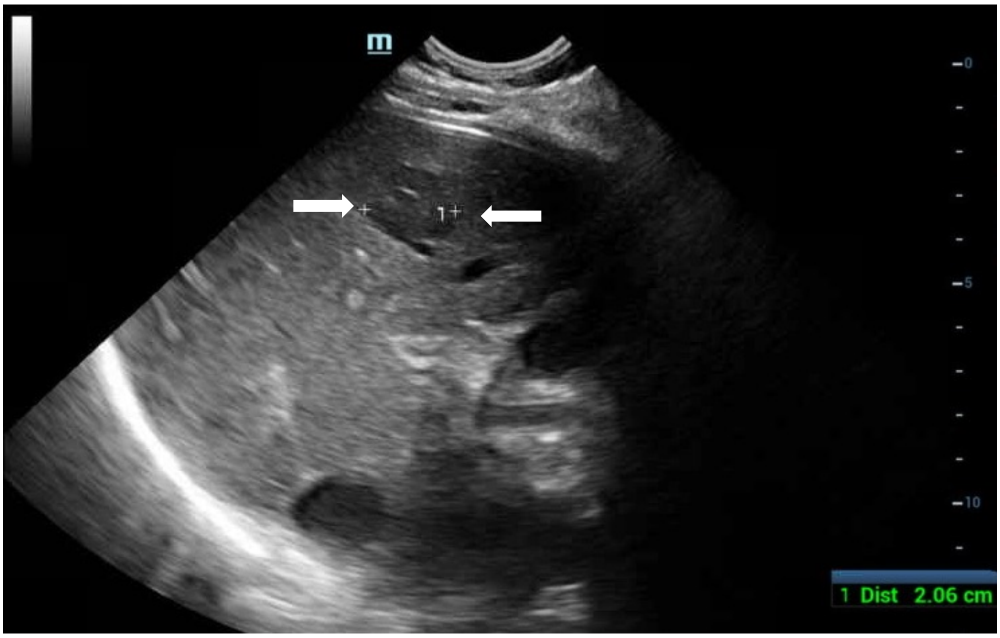
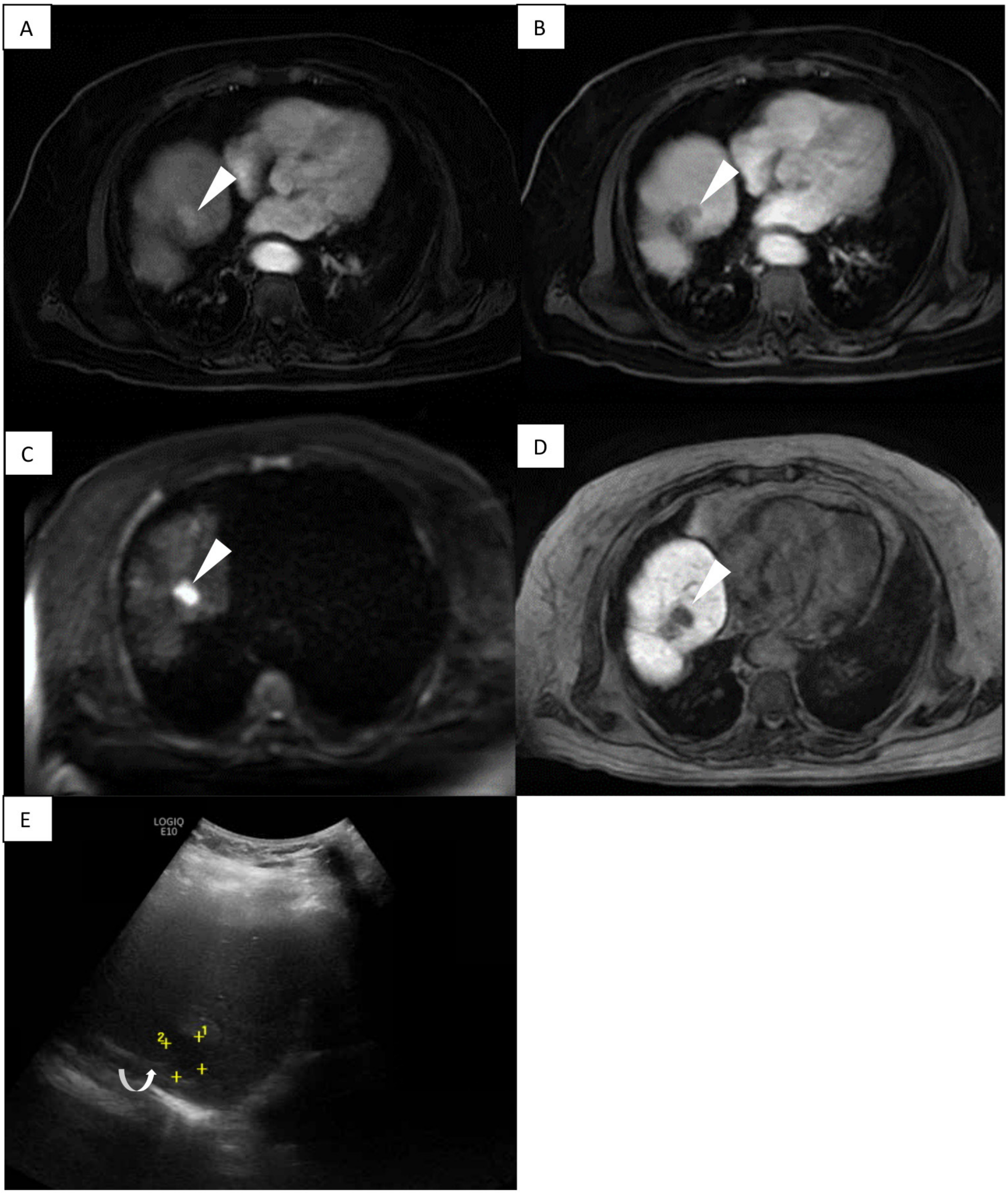



**Figure 1. Completely visible nodule on ultrasound**
*A 67-year-old male with HBV cirrhosis; the lesion appears as a well-defined hypoechoic nodule with all tumor margins clearly visualized (arrows).*


A
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E10

**Figure 2. Partially visible nodule on ultrasound**

*A 70-year-old male with NASH cirrhosis post-RFA since 2019; Routine follow-up MRI in 2022 showed a new HCC nodule at segment VIII (arrowhead) demonstrating arterial enhancement (A) with portovenous washout (B), restricted diffusion (C), and hepatobiliary defect (D). Ultrasound visualization of the entire lesion due to the high location (E), and parts of the supero-posterior border are partially obscured by air artifact from the lungs (curve arrow).*


**Figure 2. (cont.)**

*Usage of non-contrast CT in conjunction with greyscale ultrasound to confirm the tip of the ablation needle covers the target lesion and intended margins (F). The location of the needle tip is compared to the surrounding structures such as contours of the liver capsule, which is then correlated with preoperative cross-sectional imaging to improve precision and accuracy.*

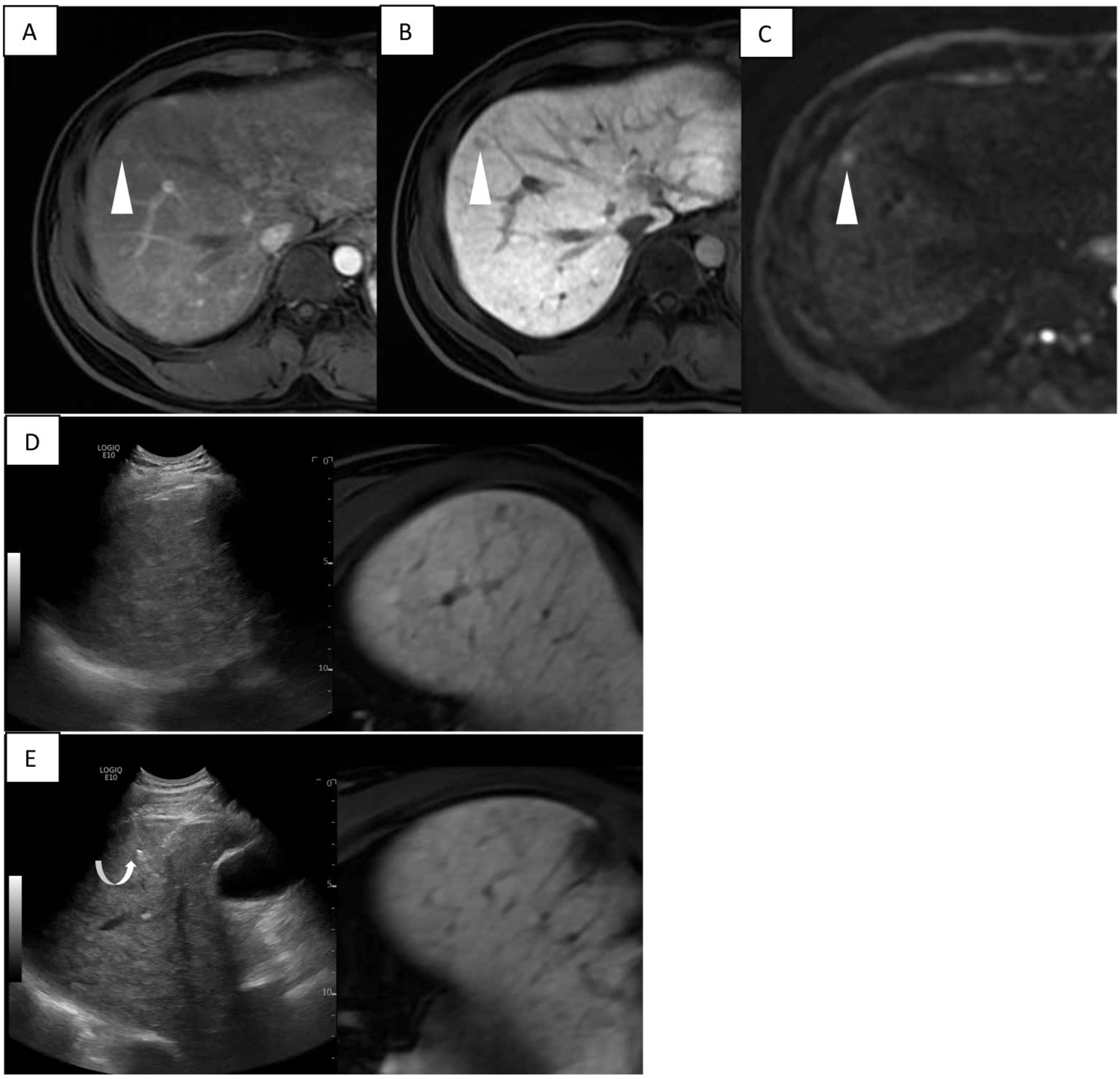


**Figure 3. Nodule invisible on ultrasound**

*A 39-year-old male with HBV cirrhosis; MRI showed a tiny faint arterial enhancing lesion (A) at segment IV/VIII (arrowhead) with hepatobiliary defect (B), and restricted diffusion (C), likely HCC. Greyscale ultrasound was unable to discern the lesion due to heterogeneous background liver parenchyma (D). Fusion US was used to assist ablation in this case (E) (Curve arrow point to the needle tip).*

**Follow Up**

Technical success was defined as complete coverage of the target lesion by the ablation zone on cross-sectional imaging performed within 4 to 6 weeks after ablation. The standard follow-up protocol of HCC patients at our institution is typically four weeks or 30 days post ablation. However, due to the high patient volume across all departments, the center services often could not feasibly schedule for the follow-up imaging within the desired 30 days. Thus, the follow-up imaging interval from the time of ablation to the initial imaging was extended to 60 days to take into an account this real-world logistical constraint in this study. All subsequent follow-up imaging was reviewed at 3 months post-ablation and at least 6 months up to 2 years post ablation to determine primary efficacy and monitor for local tumor progression at the ablation site, respectively. Primary efficacy was defined as the absence of residual viable tumor at 3-month post-ablation, and local tumor progression was defined as evidence of viable tumor despite achieving primary efficacy. The date at which local tumor progression was detected and time interval in days from the ablation procedure to date of local progression were also recorded.

**Statistical Analysis**

Descriptive variables such as age and tumor size were expressed as means with standard deviations, and categorical variables as percentages. Comparisons of characteristics between study groups were performed using the Chi-square test or Kruskal-Wallis test. Kaplan-Meier survival analysis was performed for each of the three study groups, and the log-rank test was used to compare survival outcomes between groups. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using STATA version 13.1 (StataCorp LLC).

## Results

The study population included a total of 447 unique patients and 706 lesions. Patient demographic data are depicted in Table 1. The average age of patients undergoing percutaneous tumor ablation was 66.3 years with the majority (65.9%) being males, and the most common etiology of liver disease was hepatitis B. Most of the patients were also classified as Child Pugh score A during the time of treatment.

**Table 1.** *Baseline characteristics of study population.*

| **Patient Demographics** | |
|---|---|
| Total n = 447 | |
| **Age at treatment** (years) mean (±SD) | 66.3 (11.3) |
| **Sex** n (%) | |
| Male | 295 (65.9%) |
| Female | 152 (33.1%) |
| **Viral Hepatitis** n (%) | |
| None | 123 (27.5%) |
| Hepatitis B | 207 (46.3%) |
| Hepatitis C | 114 (25.5%) |
| Both Hepatitis B and C | 3 (0.7%) |
| **Child Pugh Score** n (%) | |
| A | 402 (89.9%) |
| B | 43 (9.7%) |
| C | 2 (0.4%) |

Of the 706 lesions, 399 were classified in the complete US visibility group, 219 in the partial visibility group, and 88 in the US-invisible group (Table 2). The mean size of lesions in the complete visibility, partial visibility, and invisible groups were 1.84, 1.59, and 1.11 cm, respectively, with a statistically significant difference between the groups ($p<0.001$). The majority of lesions in the complete visibility and partial visibility groups displayed hypoechogenicity on ultrasound (56.9% and 60.3%, respectively). Regarding the ablation procedure, the majority of all groups underwent ablation using a combination of ultrasonography and non-contrast CT, followed by ultrasonography alone, usage of US with both fusion and NCCT, and finally fusion ultrasonography only. There were no statistically significant differences in the frequency of each modality combination used in each group.

**Table 2.** *Characteristics of lesions.*

| **Age (year) (mean ± SD)** | | | | |
|---|---|---|---|---|
| Total n = 706 | | | | |
| | Complete visibility N = 399 | Partially visible N = 219 | US invisible N = 88 | *p* value |
| **Size** (cm) mean (±SD) | 1.84 (±0.83) | 1.59 (±0.68) | 1.11(±0.51) | <0.001 |
| **Echogenicity** n (%) | | | | |
| Hypoechoic | 227 (56.9%) | 132 (60.3%) | - | |
| Heterogenous | 49 (12.3%) | 55 (25.1%) | - | |
| Hyperechoic | 111 (27.8%) | 26 (11.9%) | - | |
| Isoechoic | 12 (3.0%) | 6 (2.7%) | - | |
| **Guidance techniques** n (%) | | | | |
| US alone | 156 (39.1%) | 25 (11.4%) | 0 (0%) | 0.079 |
| US + NCCT | 184 (46.1%) | 139 (63.5%) | 57 (64.8%) | 0.319 |
| US + Fusion | 16 (4.0%) | 9 (4.1%) | 0 (0%) | 0.165 |
| US + NCCT + Fusion | 43 (10.8%) | 46 (21.0%) | 31 (35.2%) | 0.132 |

*US = Ultrasound, NCCT = Non-contrast computed tomography*

There were no statistically significant differences in technical success and primary efficacy among the three US visibility groups in this study (Table 3). All three groups demonstrated primary efficacy rates above 95% (p = 0.862), and primary efficacy evaluated at 3 months post-ablation of the US invisible group was slightly lower than the two other groups, 84.1% versus 95.2% and 95% for the complete visibility and partial visibility groups, respectively (p = 0.172). Similar complication rates were also observed across the three groups (p = 0.218) with most groups experiencing minor class B complications such as subcapsular hematoma which spontaneously resolved in all cases. One patient in the invisible group developed post-ablation liver abscess requiring percutaneous catheter drainage insertion for 22 days before resolution.

**Table 3.** *Ablation outcomes.*

| **Ablation Outcomes** | | | | |
|---|---|---|---|---|
| | US visible<br>N = 399 | Partially visible<br>N = 219 | US invisible<br>N = 88 | *p* value |
| **Technical Success** n (%) | | | | |
| | 382 (95.7%) | 208 (95.0%) | 86 (97.7%) | 0.862 |
| **Primary Efficacy** n (%) | | | | |
| | 380 (95.2%) | 208 (95.0%) | 77 (87.5%) | 0.172 |
| **Complications** n (%) | | | | |
| | 15 (3.8%) | 5 (2.3%) | 4 (4.5%) | 0.218 |
| Class B | 15 | 5 | 3 | |
| Class C | 0 | 0 | 1 | |

The cumulative local tumor progression-free survival at 6, 12, 24 months were 98.0%, 96.9%, and 90.5% for the complete visibility group, 98.9%, 97.9%, and 87.8% for the partial visibility group, and 96.2%, 94.5%, and 87.3% for the invisible group, respectively. There were no statistically significant differences in the cumulative survival rates among the three groups (p = 0.539) (Figure 4).

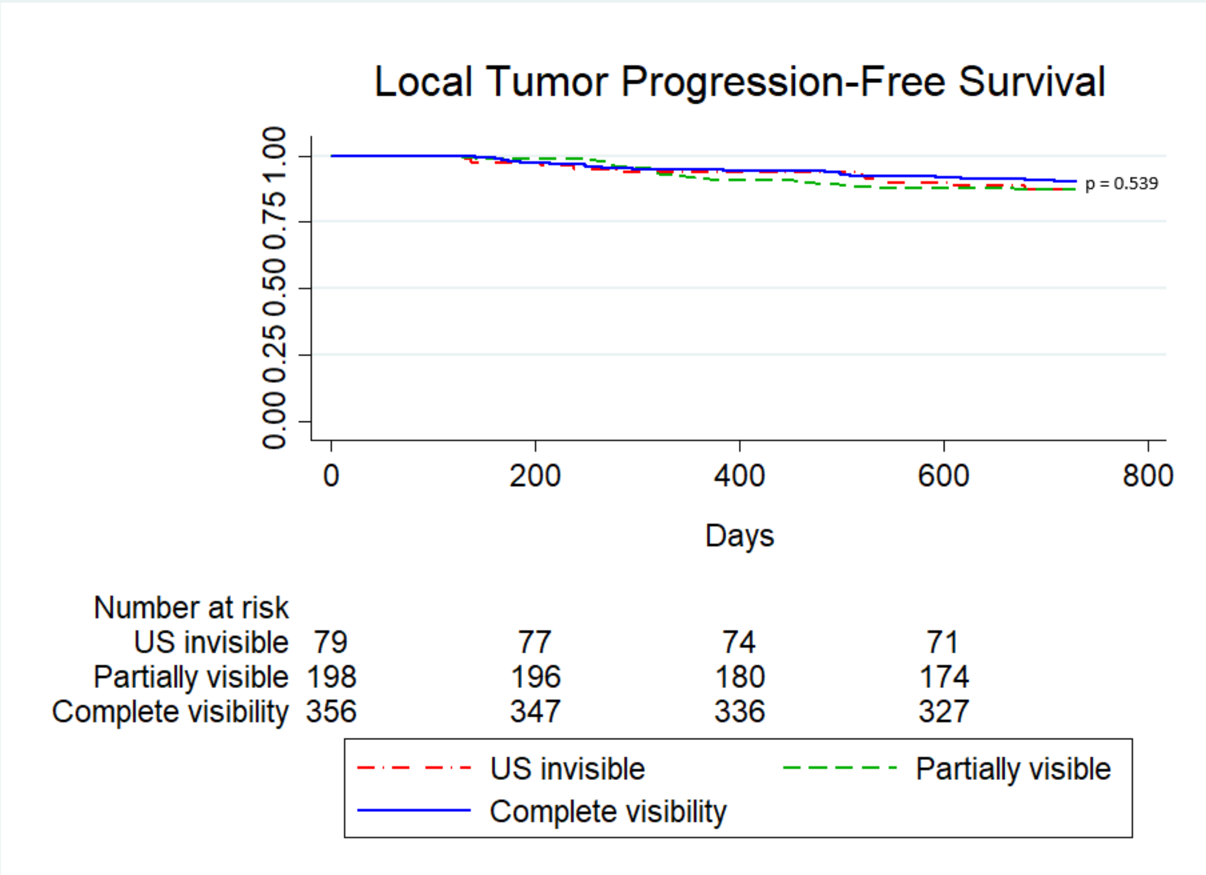


**Figure 4.** *Kaplan-Meier survival curve of local tumor progression-free survival.*

## Discussion

Percutaneous image-guided tumor ablation is a minimally invasive and widely accepted treatment option for early-stage hepatocellular carcinoma which relies on real-time ultrasonographic guidance to achieve adequate tumor ablation margins. However, the limitations of ultrasound and poor conspicuity of some HCC nodules may limit feasibility of ultrasound-guided interventions by up to 33% [4], and may cause treatment failure altogether due to mistargeting [5]. Therefore, visualization of the target lesion during placement of the ablation probe is key in performing successful ablation. Several methods have been developed to overcome the limitations of sole ultrasound guidance in order to improve the success rate of tumor ablation.

One reported technique in overcoming the problem of inconspicuous nodules is the utilization of contrast-enhanced ultrasound, where a contrast agent is injected intravenously to allow distinction between hepatic parenchyma and the target lesion [9]. Numerous studies on the usage of contrast-enhanced ultrasound (CEUS) in improving ablation success rates of inconspicuous HCC nodules have been reported in literature. Dohmen T, et al reported the efficacy of CEUS in RFA for HCC comparing outcomes between patients treated with and without CEUS. The group using CEUS showed significantly better radicality, and the non-local recurrence rate was significantly higher compared to the group without CEUS [11]. Rajesh S, et al [12] reviewed 14 patients using CEUS guided RFA of HCC and found that complete tumor ablation was achieved in all 19 lesions (in 14 patients) with no evidence of residual or recurrent tumor in the ablated areas after a mean follow-up of 16 months. Unfortunately, the contrast-enhanced ultrasound is not currently available for domestic use but may become accessible in the near future, leading to workarounds such as relying on non-contrast CT guidance or fusion ultrasonography. Fusion ultrasonography operates on the principle of a magnetic field to track the position of the ultrasound probe in 3D space in order to correlate spatial information with prior cross-sectional imaging. In theory, this allows synchronization between real-time ultrasound and cross-sectional imaging modalities such as contrast-enhanced CT or MRI [13]. However, fusion ultrasound carries potential for errors due to the fusion of static cross-sectional images with real-time ultrasound where there is respiratory motion or other subtle changes in anatomy.

This study aimed to investigate the effect of visibility of HCC nodules on the success rate of percutaneous tumor ablation, as well as the effect on the local recurrence rate and the complication rate. A total of 706 lesions were classified into three groups based on the level of visibility on ultrasound, with a statistically significant difference in size among the three groups. This could be due to the fact that the size of the nodule in the invisible group was recorded based on pre-procedural CT or MRI scan, as opposed to those complete and partial visible lesions seen on ultrasound on the day of the procedure, which could have allowed the tumor to progress in size from preprocedural imaging. Another explanation could be due to poorly visible tumor margins obfuscating the actual size of the tumor, leading to inaccurate measurement of its size. On the other hand, the small size of lesions in the invisible group may explain the difficulty in detecting the lesion on ultrasound.

There was no statistically significant difference in the success rate of ablation among the complete visibility, partial visibility, and invisible groups, with all three achieving comparable technical success rates ($p = 0.862$) which could be explained by the use of aforementioned techniques including NCCT and fusion ultrasonography to assist in precise targeting of tumors irrespective of its appearance on ultrasound. The technical success rate in this study was relatively comparable to previously reported numbers. Several studies by Minami, et al utilizing fusion US assistance in RFA of inconspicuous HCC reported technical success rates of 90% to 92% [14, 15].

As for the primary efficacy at 3 months post-ablation, there was a slightly lower tendency in the ultrasound invisible group compared to the two other groups but was not sufficient to be statistically significant ($p = 0.172$). A possible explanation for this finding could be due to the target lesion having increased in size from the time of preprocedural reference imaging to the time of procedure as mentioned previously, leading to underestimation of the tumor size and thus ablation margins leading to ultimately a slightly lower albeit statistically insignificant primary efficacy rate. Further statistical analyses may reveal significant factors contributing to the high success rate.

The local recurrence rate of the ultrasound invisible group in this study was 12.7% which is relatively high compared to previously reported numbers by Hirooka, et al [16] and Nakai, et al [17] who reported no local recurrence, albeit with smaller study populations and shorter follow-up periods than this study. However, a study by Huang, et al [8] had reported about ablation of conspicuous and inconspicuous HCC and found that the cumulative local recurrence rate after 12 months was 10% and 13% after 24 months for conspicuous HCC and 4% equally after 12 and 24 months for inconspicuous HCC. The cumulative local recurrence at 6, 12, and 24 months of the US invisible group of our study were 5 to 12% which was slightly higher than those of the complete visible and partial visible group which might be due to the underestimation of the tumor size and the ill-defined boundary. Thus, in the very poorly conspicuous cases, both fusion US and NCCT may be helpful for the imaging guidance during the ablation procedure as well as the shorter time to follow up imaging, for example, 30 days instead of 60 days.

The complication rates were also not significant between the groups, and any complications that did occur were mostly minor self-limiting complications except for a case in the US invisible lesion that developed a liver abscess following RFA where the target lesion was at hepatic segment 2 and not well visualized on ultrasound. The patient received a percutaneous drainage catheter insertion of liver abscess which was retained for two weeks after and was able to be removed successfully. Subsequent follow-up MRI revealed no adjacent bile duct injury or injury of surrounding organs, decreasing the likelihood of cause of abscess to be related to ultrasound visibility.

There are several limitations present in this study, with the most obvious being the retrospective review nature of the study which could have introduced confounding effects into interpretation of the visibility of the target lesion. Data collection on the visibility of the lesion based on the assumption that a pre-ablation ultrasound image of the target lesion would be captured and stored in PACS based on the standard protocol of our institution. And any procedure missing an image of the target lesion prior to ablation was deemed as invisible.

## Conclusion

Poor conspicuity of HCC lesions on ultrasound is a challenge for successful percutaneous image-guided ablation. The usage of ultrasound in conjunction with other modalities such as non-contrast CT scan and fusion ultrasound improves the success rate of percutaneous ablation to similar levels as conventional ablation of conspicuous nodules, while also showing comparative local tumor control without major adverse events. Future studies may adopt a prospective design approach with more robust or thorough collection on sonographic appearance of the target lesion.

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**Conflicts of Interest** - No potential conflicts of interest to disclose.

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Original Article

# Coronary artery features in the cases of atypical chest pain with a troponin-negative result

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## Abstract

**Objective:** To analyze features of coronary artery disease (CAD), which consists of (1) degrees of stenosis and (2) presence of high-risk plaque, on CT angiography (CTA) in the cases of atypical chest pain with a troponin-negative result (TNEG), using the retrospective study of 4.5-year data documents, from January 2020 to April 2024.

**Materials and Methods:** There were 270 eligible cases of atypical chest pain with a troponin-negative result (TNEG), determined by data documents via Picture Archiving and Communication System (PACS) and Hospital Information System (HIS), from January 2020 to April 2024. The known cases of CAD, status post coronary stent (s), and surgical bypass graft (s) were excluded. Cardiovascular risk factors were analyzed in the eligible cases, determined by Framingham Risk Score (FRS), the degrees of coronary artery stenosis, the degrees of coronary artery calcification, and high-risk plaque features (HRPF) on CT angiography (CTA), using the standardized CAD reporting and data system (CAD-RADS) version 2.0 (2022) of American College of Cardiology (ACC)/American Heart Association (AHA). Logistic regression, t-test, Chi-square, Spearman's correlation, and Adjusted Odd ratio were adopted to analyze the significance of variables.

**Results:** The mean age [range] of 270 eligible cases was 57 [24-90] years. Evidence of coronary artery disease (CAD-RADS 1 to 5) was found in 118 cases (43.7%). The obstructive coronary artery (≥50% stenosis, CAD-RADS 3 to 5) was present in 66 cases (24.4%). The CAD-RADS O was found in 152 cases (63.3%). The HRPF was found in 48 cases (17.8%), with a mean age [range] of 61 [42-77] years. The age group of 50 to 99 years-old showed a significant association with CAD and obstructive CAD. There were 190 cases (70%) with intermediate to high cardiovascular risk (FRS). The intermediate FRS was associated with positive CAD at 6.34 times higher than the low FRS [Multivariate adjusted OR = 6.34 (95% CI (3.16-12.73)]. The high FRS was associated with positive CAD at 10.3 times higher than the low FRS [Multivariate adjusted OR = 10.3 (95% CI (4.40-24.20)]. Moreover, there were strong correlation between CAD-RADS 0 (0% stenosis) and the coronary artery calcium score (CACS) 0-100 [0 and P1], and moderate to strong correlation between the obstructive coronary artery (CAD-RADS 3-5) and CACS ≥ 301 [P3 and P4].

**Conclusion:** Atypical chest pain with a troponin-negative result (TNEG) in the age ≥ 50-year-old with intermediate to high cardiovascular risk (FRS) had significant obstructive coronary disease (≥ 50% stenosis, CAD-RADS 3 to 5) and presence of high-risk plaque features (HRPF), determined by CT angiography.

**Keywords:** Atypical chest pain, Framingham risk score, High-risk plaque features, Obstructive coronary artery disease, Troponin-negative.

## Introduction

Atypical chest pain (or atypical angina), with the prevalence rate of 10-20% [1,2], is a common diagnosis in the emergency department (ED) and the outpatient department (OPD), usually found at the age ≥ 50-years-old. The exclusion of ischemic heart disease is only the first step in management.

According to the guidelines of the European Society of Cardiology [1,2,4], the non-invasive imaging (including CTA) can be used in all patients with a pre-test probability of >15% and can be considered in those with 5-15% of pre-test probability. The pre-test probability is based on the age and gender of the patient combined with the type of complaints: typical angina, atypical angina or non-angina chest pain.

Atypical chest pain meets two of the three criteria of the typical angina, consisting of (1) substernal chest discomfort of characteristic quality and duration, (2) provocation by exertion or emotional stress, and (3) relief by nitrates or rest within minutes. While, the non-angina chest pain does not meet the typical criteria or meets only one - several studies showed about 8.4 to 19.4% of the patients with atypical chest pain had a cardiac origin [3-6].- To exclude life-threatening causes (triple-rule-out: coronary artery occlusion, aortic dissection and pulmonary thromboembolism), the increasing amount of cardiac and thoracic computed tomography (CT) scan has been addressed in many hospitals and medical centers, in the past decades. Coronary CT angiography (CCTA) combined with the coronary calcium score (CACS) is highly sensitive and specific in the detection of coronary artery disease (CAD) and has been validated extensively [3].

The aim of the study was to analyze features of coronary artery disease on CT angiography (CTA), which consists of (1) degrees of stenosis and (2) presence of high-risk plaque, on CT angiography (CTA) in the cases of atypical chest pain with troponin-negative result (TNEG).

**Research objective**

To analyze features of coronary artery disease (CAD) on CT angiography (CTA) in the cases of atypical chest pain with troponin-negative result (TNEG), using the retrospective study of 4.5-year data documents, from January 2020 to April 2024, using CAD-RADS version 2.0.

## Materials and methods

**Study design, data collection, and participants**

This study is retrospective analysis. The participants were eligible cases of atypical chest pain with troponin-negative result (TNEG), determined by data documents via Picture Archiving and Communication System (PACS) and Hospital Information System (HIS), during January 2020 to April 2024. All eligible cases received scans with the 256-slice CT scanner Philips with the standard protocol of CTA coronary artery.

**Protocol of CTA-coronary** used retrospectively ECG-gated helical scanning. The 8 cm Z-axis coverage field-of-view (FOV) was included. The heart rate of 65 – 90 bpm was accepted for a scan. All eligible cases had no need for premedication (betablocker).

A 0.5 mm collimation was performed, showing an axial 1-beat acquisition of the entire heart. The radiation exposure is approximately 6 mSv. The image reconstruction was performed on the workstation (Philips Intelligent Space Software).

**Analysis of all coronary arteries and segments** was used under cardiac-suit software with automated reconstruction and calculation of the stenotic degrees. The radiologists approved all reconstructed images, all automatic calculation values (degrees of stenosis), and the presence of the high-risk plaque feature (HRPF).

**Inclusion criteria** were applied in all cases of the age 20-99 years old that presented with atypical chest pain and troponin-negative result (TNEG), during January 2020 and April 2024, with available CT images to PACS. The underlying diseases of all eligible cases were recorded, according to HIS.

**Exclusion criteria** were known cases of coronary artery disease (CAD), status post coronary stent (s), and status post-surgical bypass graft (s).

**Ethical consideration**
The permission for data collection was accepted on April 10, 2024. The research was approved by the Human Research Ethics Review Board of Dhurakij Pundit University. There are three principles of consideration, as follows:

(1) For the respect for person, all variables and measurements are of non-identifiable personal data. All data collection cannot project to the patient's identification.
(2) For the beneficence, there is a lower than minimal risk, and no harms to the participants in this study. The personal information and information obtained from all participants will be kept confidential. However, the results of the study and various relative factors may be disclosed to the public for academic benefits. The name of research participants was not specified.
(3) For the justice, this study has a selection of subjects with clear inclusion and exclusion, for academic benefit.

**CAD-RADS** was used for determining the coronary features. CAD-RADS stands for Coronary Artery Disease Reporting and Data System [7,8] , was used for analyzing features on coronary artery, consisting of (1) degrees of coronary artery stenosis [0%stenosis: CAD-RADS 0, 1-24% stenosis: CAD-RADS 1, 25-49% stenosis: CAD-RADS 2, 50-69% stenosis: CAD-RADS 3, 70-99% stenosis: CAD-RADS 4, and 100% stenosis: CAD-RADS 5], (2) degrees of the coronary artery calcium score (CACS) [1-100: P1, 101-300:P2, 301-999: P3, and ≥1000: P4], and (3) High-risk plaque features (HRPF), consisting of the low attenuation plaque (≤ 30 H.U.), positive remodeling, spotty calcification, and napkin-ring sign.

**Post-processing images and reports** were reviewed on PACS, consisting of 3D-cardiac image, Volume Rendering Technique (VRT) of the heart and coronary artery, Maximum Intensity Projection (MIP), Multi-planar reconstruction (MPR) of the coronary artery, the quantitative measurement for coronary artery stenosis, and evidence of high-risk plaque features (HRPF), seen in Figure 1, Figure 2, and Figure 3.

**Framingham Risk Score (FRS)** was classified into three categories: category 1: low cardiovascular risk (FRS ≤ 10%), category 2: intermediate cardiovascular risk (10% < FRS ≤ 19%), and category 3: high cardiovascular risk (FRS ≥ 20%). The potential parameters of FRS were age, gender, total cholesterol, HDL, systolic blood pressure, smoking, and diabetes.

**Statistics** used were the *t* test, Chi-square, Cramer' V, Spearman's correlation, and Logistic regression model. The adjustment of confounding factor (BMI) between FRS groups was used by adjusting the odd ratio. For all tests, p-value of <0.05 was considered to indicate statistical significance.

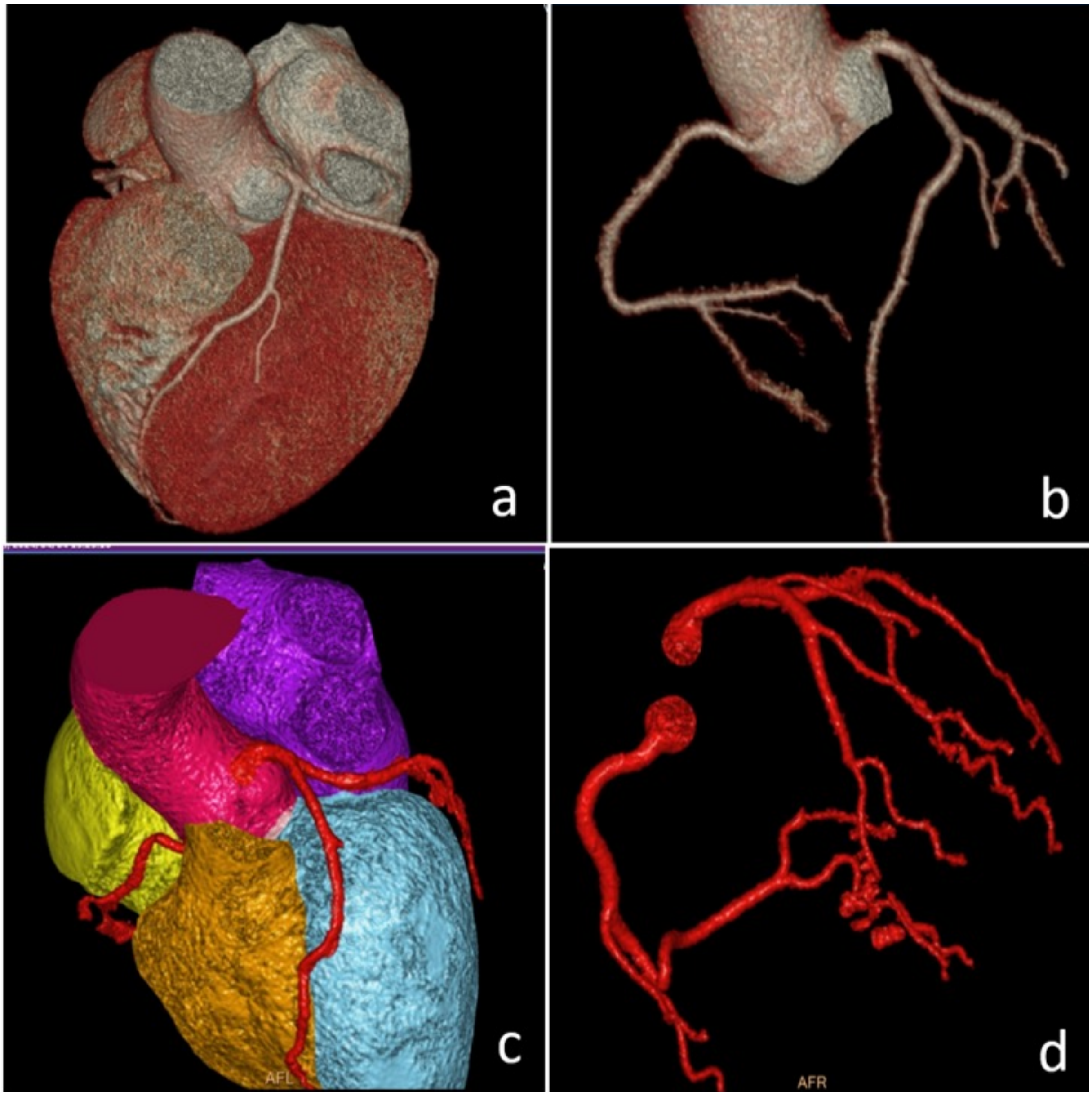


**Figure 1.** *Overview of the post-processing images on Coronary CTA, (a) 3D VRT whole heart, (b) 3D VRT coronary artery tree, (c) Color map 3D-VRT whole heart, (d) Color map VRT coronary artery tree.*

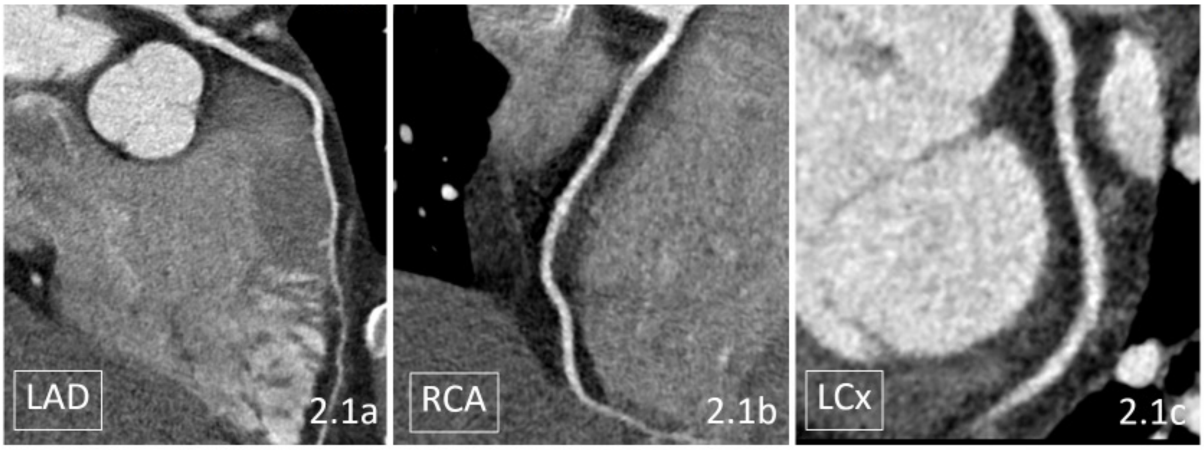


**Figure 2.** *Classification of coronary artery stenosis (CAD-RADS) and plaque burden (P),*

**Figure 2.1a-c:** *Multi-planar reconstruction (MPR) of the coronary artery showed CAD-RADS 0, no coronary stenosis, absence of calcified and non-calcified plaque in the coronary tree, the classification P is not required for CAD-RADS 0,*

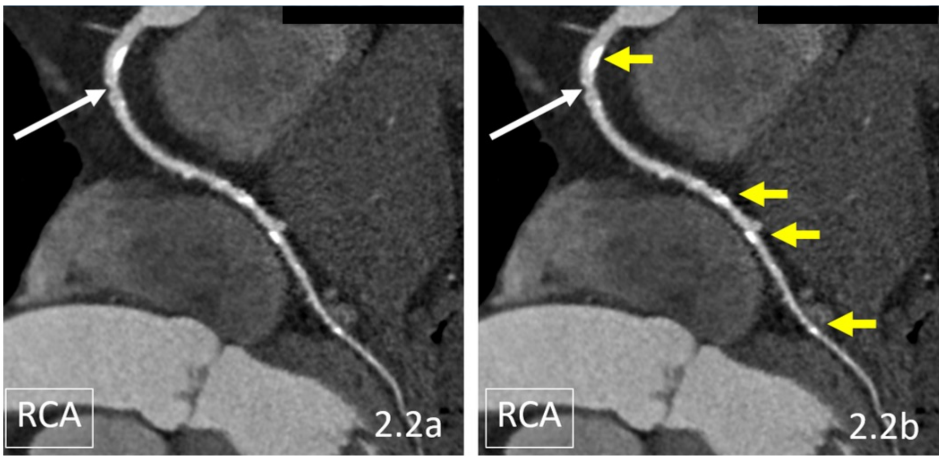


**Figure 2.2a-b.** *Multi-planar reconstruction (MPR) of the coronary artery showed CAD-RADS 1/P1 - Minimal coronary stenosis (1–24%). Figure 2.2a (a long white arrow) identified a non-calcified plaque with 20% stenosis at proximal RCA. Plaque Burden –P1: Mild amount of plaque burden. Figure 2.2b (yellow arrows) identified calcified plaques. CACS = 86.8,*

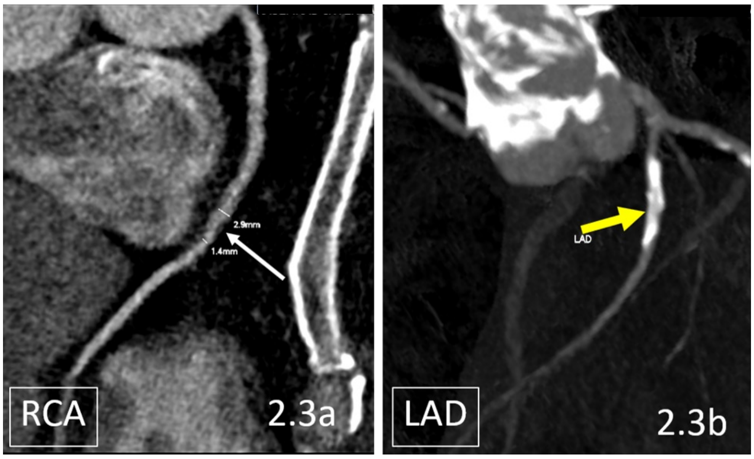


**Figure 2.3a-b.** *Multi-planar reconstruction (MPR) of the coronary artery showed CAD-RADS2/P2 - Mild coronary stenosis (25-49%). Figure 2.3a (a long white arrow) identified a non-calcified plaque with 45% stenosis at the middle segment RCA. Plaque Burden –P2: Moderate amount of plaque burden. Figure 2.3b (a yellow arrow) identified a "sheet- like" heavy calcification at proximal LAD. CACS = 267.71,*

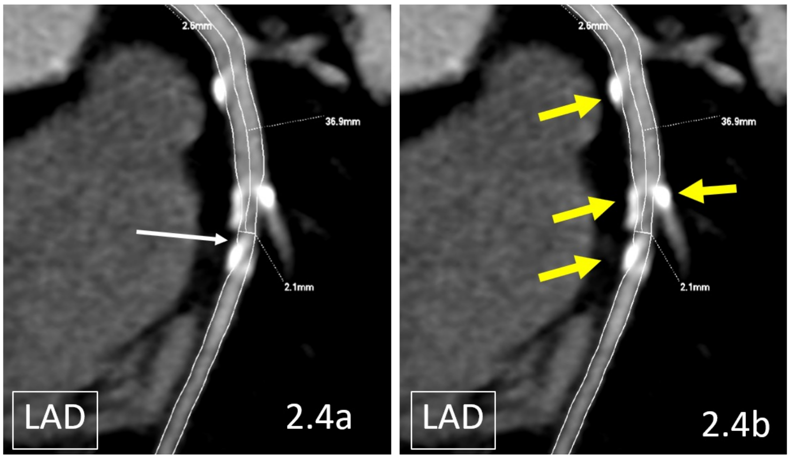


**Figure 2.4a-b.** *Multi-planar reconstruction (MPR) of the coronary artery showed CAD-RADS 3/P3 - Moderate coronary stenosis (50-69%). Figure 2.4a (a long white arrow) identified using a non-calcified plaque with 55% stenosis at the middle segment LAD. Plaque Burden –P3: Moderate amount of plaque burden; Figure 2.4b (yellow arrows) identified several calcified plaques along proximal and middle segments LAD. CACS = 426.5,*

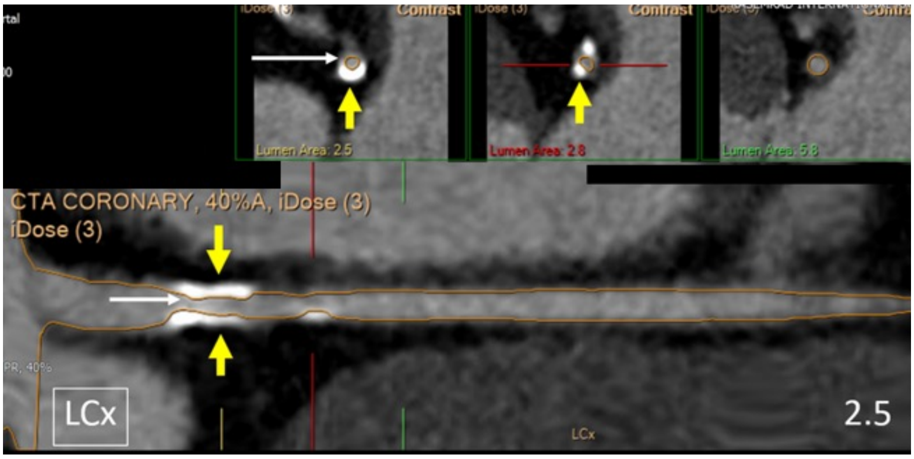


**Figure 2.5.** *Multi-planar reconstruction (MPR) of the coronary artery showed CAD-RADS 4/P4 - Severe coronary stenosis (70-99%). A long white arrow identified a non-calcified plaque with 75% stenosis at the origin and proximal LCx. Plaque Burden –P3: Severe amount of plaque burden (yellow arrows); CACS = 1007.93,*

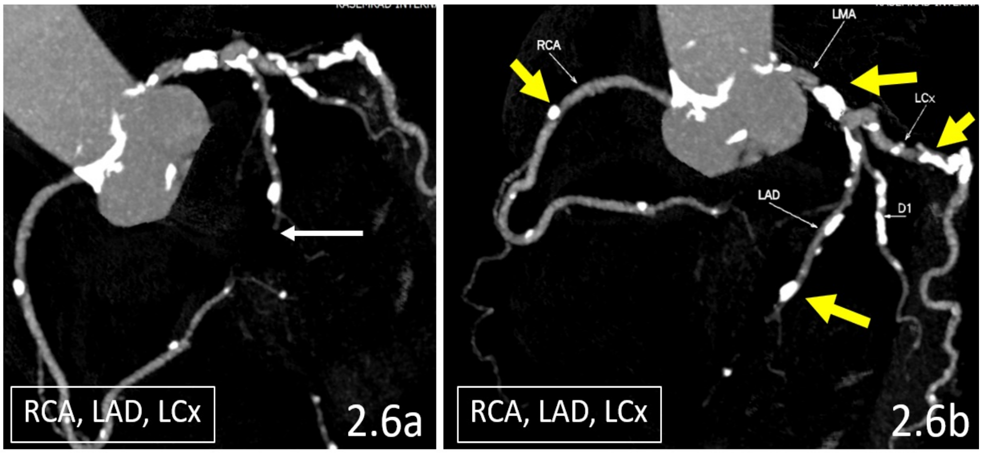


**Figure 2.6a-b.** *Maximum Intensity Projection (MIP) of coronary artery showed CAD-RADS 5/P4 – an occluded coronary stenosis (100%) at middle segment LAD (Figure 2.6a: a long white arrow). Plaque Burden –P4: Extensive amount of plaque burden along the course of all coronary arteries (Figure 2.6b: yellow arrows). CACS = 1,349.95.*

## Results

The mean age [range] of 270 eligible cases was 57 [24-90] years. The median BMI [IQR] was 25.39 [22.8-29.0]. The baseline characteristics are presented in Table 1 and Table 2. There was no significant difference between genders and age groups (unpaired t-test, p-value =0.97). The percentage of the cases with low Framingham Risk Score (FRS), intermediate FRS, and high FRS was 29.6% (n=80), 52.6% (n=142), and 17.8% (n=48), respectively.

There was a significantly strong correlation between the 100% coronary artery stenosis [CAD-RADS 5] and the extensive coronary calcification [CACS ≥1000, P4] (Spearman's correlation = 0.80). A moderately correlation between the 50% to 99% coronary stenosis [CAD-RADS 3 and 4] and CACS 301-999 [P4] was seen (Spearman's correlation = 0.72 and 0.65, respectively). On the other hand, there was a significantly strong correlation between the CAD-RADS 0 (0% stenosis) and the CACS 0-100 [0 and P1] (Spearman's correlation = 0.84 and 0.82, respectively), seen in Table 3.

There was a significant association between age groups of 50-99 years and the positive coronary artery disease (CAD) and the obstructive CAD (stenosis ≥ 50%) [$\chi^2$= 38.069 and 35.897, Cramer's V = 0.37 and 0.36, respectively], seen in Table 4.

On the other hand, there was a significant association between age groups of 20-49 years and the negative CAD and the non-obstructive CAD, seen in Table 4.

The cases of intermediate FRS were associated with positive CAD at 6.34 times more than the low FRS [Multivariate adjusted OR = 6.34 (95% CI (3.16-12.73)]. The cases of high FRS were associated with positive CAD at 10.3 times more than the low FRS [Multivariate adjusted OR = 10.3 (95% CI (4.40-24.20)], seen in Table 5.

Moreover, there was a significant association between the high-risk plaque features (HRPF) and the obstructive CAD [ $\chi^2$ = 37.174, Cramer's V = 0.56], seen in Table 6.

**Table 1.** *Baseline characteristics of the eligible cases (n = 270).*

| | |
|---|---|
| **Mean age years** [range] | 57 [24-90] |
| **Male, n** (%) | 134 (49.6%) |
| **Body mass index (kg/m2) median** [IQR] | 25.39 [22.8-29.0] |
| **Diabetes, n** (%) | 51 (18.8%) |
| **Hypertension, n** (%) | 155 (57.4%) |
| **Dyslipidemia, n** (%) | 46 (17.0%) |
| **Smoking, n** (%) | 13 (4.8%) |
| **Low Framingham Risk Score** (<10%), **n** (%) | 80 (29.6%) |
| **Intermediate Framingham Risk Score** (<10-19%), **n** (%) | 142(52.6%) |
| **High Framingham Risk Score** (≥ 20%), **n** (%) | 48 (17.8%) |

**Table 2.** *Baseline characteristics on age groups and genders of eligible cases with atypical chest pain and troponin-negative (n = 270).*

| Age (yrs.) | Male (n =134, 49.6%) | Female (n = 136, 50.3%) | Total |
|---|---|---|---|
| 20-29 | 3 | 4 | 7 (2.6%) |
| 30-39 | 14 | 8 | 22 (8.1%) |
| 40-49 | 29 | 22 | 51 (18.9%) |
| 50-59 | 40 | 29 | 69 (25.5%) |
| 60-69 | 31 | 42 | 73 (27.0%) |
| 70-79 | 15 | 22 | 37 (13.7%) |
| 80-89 | 1 | 9 | 10 (3.75%) |
| 90-99 | 1 | 0 | 1 (0.37%) |
| Total | 134 | 136 | 270 |

*The unpaired t-test, p-value = 0.97*

**Table 3.** *Correlation of coronary features between the coronary artery calcium score (CACS) and the degrees of coronary artery stenosis (CAD-RADS)*.*

| CAD-RADS / CACS | CAD-RADS 0 0% stenosis | CAD-RADS 1 1-24 % stenosis | CAD-RADS 2 25-49 % stenosis | CAD-RADS 3 50-69 % stenosis | CAD-RADS 4 70-99 % stenosis | CAD-RADS 5 100 % stenosis | n = 270 |
|---|---|---|---|---|---|---|---|
| **CACS = 0** (n) | 88<br>***0.84** | 7<br>*0.43 | 5<br>*-0.10 | 5<br>*-0.19 | 1<br>*-0.67 | 0<br>*-0.30 | 106 |
| CACS 1-100 (n)<br>**[P1]** Mild | 54<br>***0.82** | 3<br>*0.45 | 6<br>*-0.13 | 1<br>*-0.20 | 3<br>*-0.61 | 0<br>*-0.25 | 67 |
| CACS 101-300 (n)<br>**[P2]** Moderate | 10<br>*0.17 | 9<br>*-0.20 | 9<br>*-0.98 | 6<br>*-0.47 | 12<br>*0.22 | 0<br>*0.72 | 46 |
| CACS 301-999 (n)<br>**[P3]** Severe | 0<br>*-0.88 | 3<br>*-0.01 | 10<br>*0.54 | 12<br>***0.72** | 6<br>***0.65** | 0<br>-0.02 | 31 |
| CACS > 1000 (n)<br>**[P4]** Extensive | 0<br>*-0.68 | 0<br>*-0.79 | 0<br>*-0.47 | 7<br>*0.60 | 11<br>*0.44 | 2<br>***0.80** | 20 |
| **Total (n)** | 152 | 22 | 30 | 31 | 33 | 2 | **270** |

**Spearman's correlation*

**Table 4.** *Association between the age groups and coronary artery disease (CAD), and the obstructive coronary artery disease (stenosis > 50%).*

| Age groups (years) | CAD (n=118) | Non-CAD (n=152) | P-value | Obstructive CAD (n = 66) | Non-obstructive CAD (n= 52) | P-value |
|---|---|---|---|---|---|---|
| **50 -99** | 106 | 84 | < 0.001* | 61 | **25** | < 0.001** |
| **20- 49** | 12 | 68 | < 0.001* | 5 | 27 | < 0.001** |

* $\chi^2$ *= 38.069, degree of freedom = 1, Cramer's V = 0.37* * *P-value < 0.05*
** $\chi^2$ *= 35.897, degree of freedom = 1, Cramer's V = 0.36* ** *P-value < 0.05*

**Table 5.** *Logistic regression model of the positive coronary artery disease (CAD) in the eligible cases, determined by Framingham Risk Score (FRS)*.*

| Eligible cases with Framingham Risk Score (FRS) | No. of cases with CAD (n=118) | Multivariate adjusted OR (95% CI) |
|---|---|---|
| **Low Framingham Risk Score** (<10%) | **12** | 1.00 (reference) |
| **Intermediate Framingham Risk Score** (<10-19%) | **75** | 6.34 (3.16-12.73) |
| **High Framingham Risk Score** (> 20%) | **31** | 10.3 (4.40-24.20) |
| **P for trend < 0.001**** | | |

**Logistic regression model was used to estimate OR and 95% CI [Adjusted BMI and Diabetes]*
*** P-value < 0.05*

**Table 6.** *Association between the high-risk plaque features (HRPF) and the coronary artery disease (CAD-RADS 1 to 5).*

| | Presence of HRPF | Absent of HRPF | P-value |
|---|---|---|---|
| **Obstructive CAD (n = 66) [CAD-RADS 3, 4, and 5]** | 43 | 23 | < 0.001* |
| **Non-obstructive CAD (n= 52) [CAD-RADS 1 and 2]** | 5 | 47 | < 0.001* |

* $\chi^2$ *= 37.174, degree of freedom = 1, Cramer's V = 0.56* **P-value < 0.05*

## Discussion

### 1. Role of coronary CTA in the cases of atypical chest pain

According to the guidelines of the European Society of Cardiology [1,2,4], the non-invasive imaging (including CTA) can be used in all patients with a pre-test probability of >15% and can be considered in those with a pre-test probability between 5-15%. The pre-test probability is based on the age and gender of the patient combined with the type of complaints: typical angina, atypical angina or non-angina chest pain.

The current meta-analysis of 5332 patients from 65 prospective diagnostic accuracy studies [9] that compared the accuracy of Coronary CT angiography (CCTA) with cardiac catheterized coronary angiography in patients with any clinical probability of coronary artery disease (CAD) showed the overall sensitivity of CTA accounting for 95.2% (92.6% to 96.9%) and the specificity of 79.2% (74.9% to 82.9%) and was not significantly influenced by the angina pectoris type (typical angina, atypical, non-angina chest pain).

The available CCTA has a useful benefit as rapid non-invasive diagnostic tool in the case of atypical chest pain with intermediate to high cardiovascular risks, especially among 50-99-year-old age group, to exclude life-threatening cardiovascular causes (triple-rule-out: coronary artery occlusion, aortic dissection, and pulmonary thromboembolism).

### 2. Obstructive CAD and atypical chest pain

According to AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline 2021 [10], the intermediate-high risk patients have modest rates of obstructive CAD (~10%–20%) and a risk of clinical events (~1%–2% per year). CCTA is preferable in those < 65 years of age and not on optimal preventive therapies, while stress testing may be advantageous in those ≥ 65 years of age, because they have a higher likelihood of ischemia and obstructive CAD.

The top five of the causes of chest pain, at the age of 45-64 years, are (1) non-specific chest pain, about 56% of the population, followed by (2) coronary atherosclerosis, (3) painful respiration, (4) acute myocardial infarction, and (5) cardiac dysrhythmia [10].

In the cases of atypical chest pain with diabetes [6], there was a presence of extensive CAD, as well as more obstructive CAD, particularly in women.

As compared with our study, the obstructive CAD was found in 24.4% of eligible cases that presented with atypical chest pain and TNEG. Obstructive CAD should be concerned in the case with intermediate to high cardiovascular risks (FRS).

**3. High-risk plaque features and CAD**

High-risk plaque features (HRPF), consist of the low attenuation plaque (≤ 30 H.U.), positive remodeling, spotty calcification (<3mm), and napkin-ring sign. HRPF can be found in obstructive CAD and non-obstructive CAD, more likely in the obstructive CAD [11,12,13,14]. HRPF tends to rupture with subsequent intraluminal formation of thrombi which causes acute myocardial infarction (AMI) [13].

In 2018, the meta-analysis and systematic review [14] demonstrated that HRPF is most likely an independent predictor of major adverse cardiovascular events (MACE), which supports the inclusion of HRPF reporting in clinical practice. However, at this point, it remains unclear whether HRPF reporting has clinical implications.

The recent study on 2024 [15] showed the significant progression in the number of the high-risk plaques in the cases of non-obstructive coronary disease. The HRPF needs further studies, especially one related to radio-pathologic-clinical correlation.

# Conclusion

**Conclusion and suggestion**

Coronary CT angiography (CCTA) appears to be a useful initial triage tool in the cases of atypical chest pain. When the CCTA result is negative, it allows safe early discharge because of its high negative predictive value. In the selected cases of the age > 50-year-old with intermediate to high cardiovascular risks (FRS), CCTA can detect the obstructive coronary disease and high-risk plaque features (HRPF) and allow further therapeutic intervention.

For ED physicians and cardiologists, the CCTA should be used more routinely in TNEG patients with intermediate to high cardiovascular risk, especially among 50-99-year-olds, to exclude life-threatening coronary artery obstruction.

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Letter to the Editor and Reply

# Radiology OPD: A new model for radiology referrals in modern healthcare

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## Introduction

"A disease diagnosed is half-cured"! This quote by Thomas Fuller correctly highlights the importance of correct diagnosis in clinical medicine and emphasizes the role of radiology as the backbone of modern healthcare. There are instances in which patients visit the out-patient department [OPD] with previous consultations, laboratory and imaging reports, and uncertain diagnoses. Despite the work-up elsewhere, the diagnosis remained unclear, and treatment was ineffective, and the patient remained a continued diagnostic challenge.

The key reasons may be an incorrect approach to diagnostic work-up or sub-optimal scan quality or inappropriate interpretation by a radiologist working in a clinical vacuum. This may also be due to a lack of a comprehensive approach to the patient's problem, which is not unusual in modern healthcare, as it has become overly specialized and often fragmented. Specialization in Medicine is certainly necessary to delve deep into the vast sea of knowledge, but maintaining a working knowledge across specialties is crucial. When closely examining a single tree, one should not lose sight of the forest [1].

Value is the most important factor in defining the effectiveness of healthcare delivery which may be translated as product of patient experience and the clinical outcome [2]. 'Value-based healthcare' aims to improve individual healthcare outcomes with appropriate use of resources without increasing costs. A multi-society expert statement clearly defined the role of Radiology in a 'Value-based healthcare' [3]. Accordingly, radiologists may need to gradually adopt 'value-based practice' rather than the 'volume-based practice' to positively impact patient care and outcomes. A triad consisting of a primary care group, a radiology group, and a clinical laboratory is likely to solve 90% of the diagnostic dilemmas in routine clinical practice [4]. Four components which should be integrated in the clinical radiologist's work profile are – review of the imaging requests to assess appropriateness, scan monitoring to ensure quality, interpreting/reporting and consulting with referring clinicians and patients [5]. Three out of four components are often missing and should be addressed.

With an objective to address this problem and to bridge the stated gaps, we initiated a pilot project in the department of Radiology at Indraprastha Apollo Hospital, New Delhi, India – Radiology Out-Patient Department [OPD].

**Contents**

The project created an additional referral pathway for the clinicians refer patients to the department of Radiology (Figure 1).

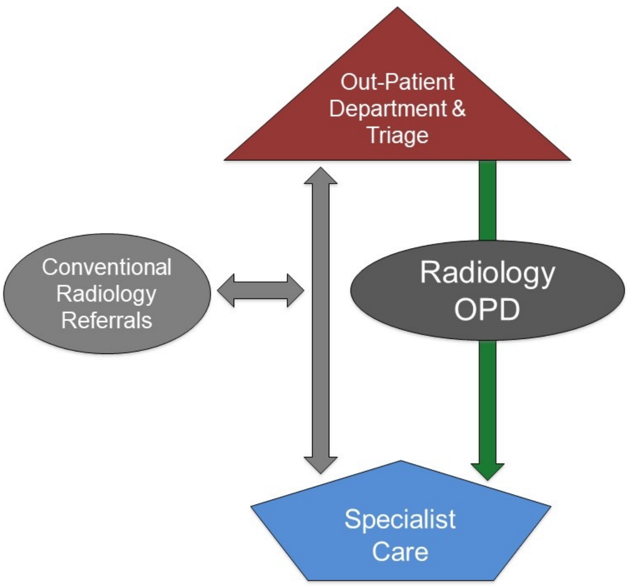


**Figure 1.** *shows the outline of the workflow in the Radiology department, whereby the radiology OPD serves as an additional alternative pathway for the patient referral from the outpatient department/triage to specialist care. The conventional radiology referrals remain unchanged and continue to serve as before. As per the new model, the referring clinician will decide the preferred referral pathway based on the patient's clinical profile.*

Accordingly, in case of patients presenting with a diagnostic challenge or an uncertain diagnosis, the clinician may decide to refer them to radiology OPD for a detailed diagnostic work-up without advising any imaging studies themselves. These patients consult radiologists in radiology OPD. The radiologists review the complete clinical history, previous laboratory reports and imaging studies and accordingly discuss the diagnostic workup and advise the most appropriate imaging study. Radiologists supervise the imaging study to ensure a correct and 'individualized' protocol for maximum diagnostic benefits. Radiologists then interpret the results, in correlation with the clinical presentation and compare it with the prior scans to reach the most possible diagnosis. Radiologists explain the results and implications and potential treatment options to patients and subsequently discuss the cases with the referring clinicians and assist in the treatment/surgical plan.

Radiology OPD is not planned or designed to replace the 'conventional referral pathway' where patients are referred to the radiology department for a specific imaging study. Radiology OPD is meant for the select group of out-patients [not for in-patients] who presents with persistent diagnostic uncertainties. Unlike the conventional referral pathway, patients visiting the Radiology OPD need to pay the additional consultation fee apart from the charges for imaging studies. The charges for imaging studies remain unchanged in the two pathways. The decision to select the patients for each referral pathway depends on the clinician, under the patient's consent.

Till date, a total of 56 patients (32 males and 24 females) attended the radiology OPD in 4 months for varied clinical indications. The review showed high diagnostic accuracy (>95%) with reasonable turn-around times (24-48 hours] without any inappropriate scans or scan repetitions.  These included patients showing high satisfaction rates for the 'personalized' radiology services. The overall impact over the clinical course of the disease was found to be favourable till the time of this analysis.

Direct patient consultation in Radiology is likely to be a giant leap towards the 'patient-centric approach' in healthcare. Several studies have reported higher patient satisfaction rates and improved compliance with the follow-up scans when they get the chance to understand their imaging results from the reporting radiologists [6,7]. Diagnostic radiology consultation clinic was integrated into the everyday workflow at the Department of Radiology, Massachusetts General Hospital and Harvard Medical School, Boston, US which reported a high level of patient satisfaction and improved understanding of the role of a radiologist [8]. Unlike our model, this clinic was, however, confined to the communication of the most recent study findings and still missed two out of the four components of the clinical radiologist's work profile [5]. In our model, the diagnostic radiology consultation is chargeable which does not adversely affect the radiologist's productivity and the hospital's revenue.

Few referring clinicians may be apprehensive about the direct communication of imaging results to the patients by the reporting radiologists [9]. Radiologists should seek to establish a mutually agreeable practice while initiating such a diagnostic radiology consultation clinic.

Radiological Society of North America and American College of Radiology have launched campaigns to help radiologists adopt a more patient-centred practice. These campaigns have emphasized the role of direct patient consultations to improve the patient's experience and to enhance the value of healthcare [10,11].

Even though radiologists are conventionally seen as 'doctors' doctors', the evolution of radiology and demand for 'value-based healthcare' will gradually transform them into 'patients' doctors'. This was also stated in an AJR editorial, dated back in 1977 [12] and is even evident in our new model for radiology referrals and consultations.

'Radiology OPD' will allow radiologists to review the imaging appropriateness, scan monitoring, clinical interpreting/ reporting and consulting with the referring clinicians and patients. This comprehensive 'patient-centric' model is expected to enhance patients' experience, improve outcomes, minimize unnecessary scans and allow a transition of radiology from a 'volume-based' to 'value-based' approach.

## Conclusion

The pilot study based on this new model of 'Radiology OPD' showed promising results with significant positive impact on the clinical course in outpatient department settings in our hospital. By providing a comprehensive review of patient information and tests conducted in a radiology outpatient clinic, we improved patient outcomes, reduced repetition and wastage and thereby reduced our greenhouse gas emissions. We believe it will pave the transition from a volume-based to value-based approach in healthcare, enhance clinical outcomes and even elevate the radiologist's profile.

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## Reply to Letter to the Editor

I refer to the Letter to the Editor, Radiology OPD: A new model for radiology referrals in modern healthcare by Dr. Nitin Ghonge. I read with interest this pilot project of a radiology outpatient department [OPD] where direct referrals are made to the experienced radiologist whose primary aim is to try to solve the diagnostic conundrum for the patient and the referring doctor. Congratulations to the author and those in the team that brought this project into fruition as it is value-based radiology in action and definitely improves patient outcomes whilst reducing any unnecessary or inappropriate testing. The latter contributes to environmental sustainability in radiology and reduces costs for the payor.

A few features of this model exemplify radiologists as clinicians [1,2,3,4]. Radiologists used to more regularly have face to face discussions with referring doctors, especially prior to digitization with Picture Archiving and Communication System (PACS) and higher sectional imaging workload volumes. The referring doctors would discuss their patients with radiologists who had the full range of the clinical information including all prior diagnostic tests and previous imaging for comparison. Whilst with electronic medical records, it is theoretically possible and advisable to check the patient's medical history, in reality, the time taken and tediosity of the process may make it challenging in a very busy setting.

Another aspect is patient communication – actually talking to patients about their complaints and obtaining a history that would help radiologists decide on the most appropriate imaging related investigation and improve interpretation of the imaging study [5,6] Radiologist-patient: explaining what next diagnostic imaging tests will be done, why, what to expect and subsequently talking to the patient about the findings/results also improves patient satisfaction and outcomes [5,7].

Finally, in this radiology OPD model, radiologists are paid for their consultation time. In many situations, this may be more difficult to implement as challenges include the reimbursement models whether government, insurance or self-payment (out-of-pocket) and fee-for-service interpretation of studies, reading workload and shortage of radiologists. However, the author has shown that it is possible for radiologists (not just interventional radiologists) to have a consultation clinic particularly for diagnostic challenges. I look forward to more centres in Asia adopting or at least trialling this model that will raise the profile of radiologists and make them visible once again.

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Initiative / Innovation

# 5T MRI: Bridging innovation and whole-body clinical need

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## Abstract

This article introduces the clinical debut of whole-body 5T magnetic resonance imaging (MRI), a novel ultra-high-field system designed to bridge the gap between conventional 3T and 7T MRI. Developed through international collaboration, the 5T platform overcomes major technical barriers in RF design, field homogeneity, and SAR control, to enable stable, high-resolution imaging across the whole body. Clinical evidence demonstrates its superiority in multiple applications, including intracranial vascular imaging, cardiac and coronary assessment, and abdominal imaging. By delivering both ultra-high resolution and whole-body capability, 5T MRI establishes a new paradigm for clinical imaging and paves the way for broader access to advanced diagnostic technologies.

**Keywords:** Abdominal, Cardiac, MRI, TOF MRA, Ultra-high-field MRI, 5.0T MRI.

It is a great honor to participate in RCRT-RST 2025. This year's theme, "The Art and Science of Radiology: Bridging Knowledge and Practice," reflects a shared commitment across our community — to translate technological progress into meaningful clinical outcomes.

In this context, I would like to introduce the clinical debut of ultra-high-field whole-body 5.0T MRI. It enables radiologists to see subtle findings that were previously difficult to detect — and in doing so, helps us "see the unseen" and improve diagnostic confidence.

**Part I. The Evolution of MRI: From Low Field to Ultra-high Field**

MRI has undergone remarkable progress over the past four decades — from low-field systems with limited capabilities to 1.5T and 3.0T scanners that became the mainstay of clinical imaging. Each leap in field strength has brought new possibilities in spatial resolution, image quality, and diagnostic accuracy.

In 2017, the U.S. FDA approved the first 7T MRI system for clinical use, but its clinical applications primarily limited to the head and extremities [1]. Meanwhile, clinical demands continue to evolve. Radiologists are increasingly in pursuit of both ultra-high resolution and whole-body imaging capabilities — spanning the brain, joints, heart, abdomen, breast, and spine.

**Part II. The Birth of 5T MRI: Bridging Vision and Feasibility**

Several years ago, Professor Jürgen Hennig, a pioneer and former president of ISMRM, said, "The Tesla has to come to the clinic, not the clinic to the Tesla." Prof. Hennig is widely regarded as a living legend in the field of MRI and the inventor of the Fast Spin Echo sequence, who proposed the idea of 5.0T MRI as a feasible clinical alternative to 7T. I knew him in 2008 and later joined his lab at the University of Freiburg in 2016. His vision of a clinically meaningful ultra-high-field MRI system profoundly inspired my own path in MRI development.

However, the development of a 5.0T MRI system was technically challenging. Operating at this field strength required major breakthroughs in the RF system design, B0 and B1 field management, coil optimization, and SAR control to ensure stable and high-quality imaging across the whole body.

After years of collaborative innovation between engineers, physicists, and clinical experts, the world's first whole-body 5.0T MRI scanner was successfully developed in China. It received both U.S. FDA clearance and CE certification in Europe, and its clinical use is rapidly expanding.

**Part III. Clinical Impact of 5T MRI: See the Unseen**

5.0T MRI is far more than just a technological advancement—it represents a new paradigm in whole-body clinical imaging. By bridging the gap between 3.0T and 7.0T, it delivers unparalleled image quality while maintaining workflow efficiency and patient accessibility.

In brain imaging, 5.0T MRI demonstrates significant advantages in visualizing distal arterial segments and small perforating branches. A recent prospective study comparing 3T, 5T, and 7T TOF-MRA found that 5T imaging provided notably better visualization of the lenticulostriate and pontine arteries than 3T, with vessel detail approaching that of 7T [2]. Quantitatively, the total length of small vessel branches detected at 5T was more than twice that of 3T, with no significant difference compared to 7T. These results confirm that 5T TOF-MRA offers both the resolution and stability needed for high-quality intracranial vascular imaging, making it a clinically viable tool for detecting small vessel diseases and assessing a complex cerebrovascular anatomy.

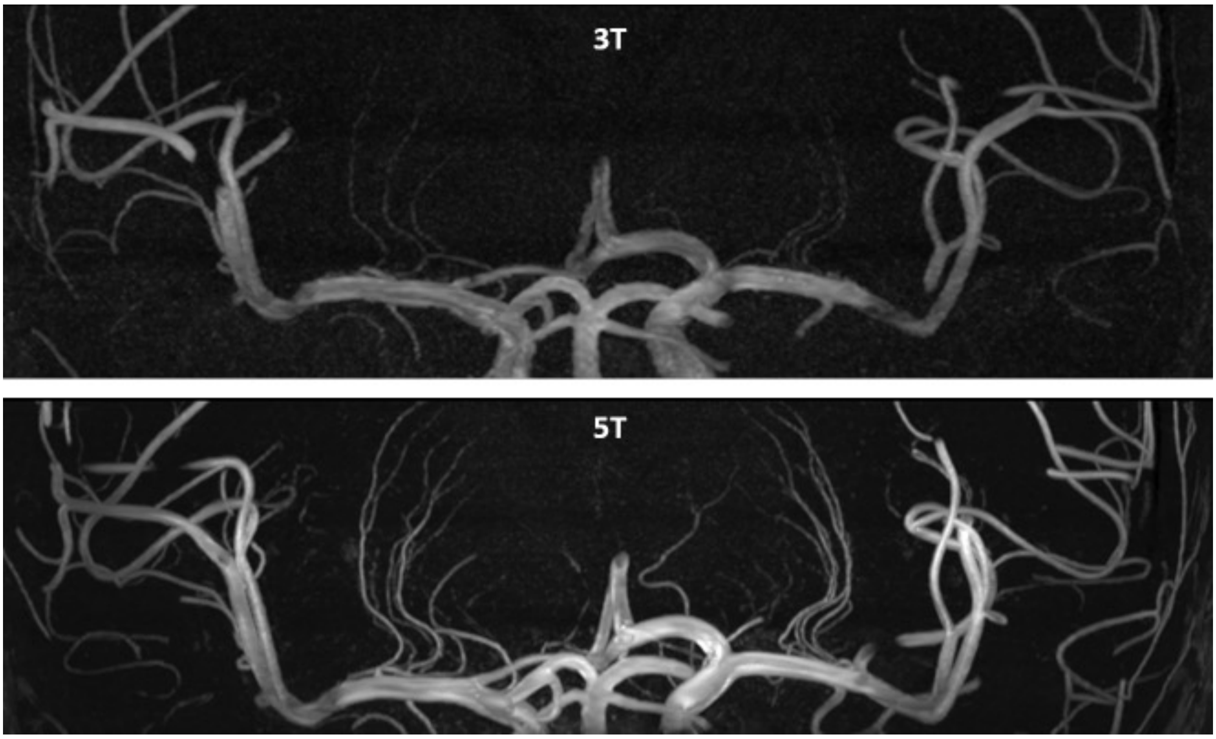


**Figure 1.** *Time-of-flight (TOF) intracranial MRA at 3.0T (top) and 5.0T (bottom), acquired with identical voxel size (0.40 × 0.40 × 0.40 mm³) and scan time; 5.0T TOF-MRA shows more continuous and well-defined visualization of the lenticulo-striate arteries and distal branches compared to 3.0T.*

In cardiovascular imaging, 5.0T MRI has demonstrated clear benefits in both coronary and myocardial applications. For non-contrast coronary MRA, recent prospective studies have shown that 5T achieves significantly higher SNR, CNR, and vessel edge sharpness compared to 3T, while maintaining shorter scan times [4]. In myocardial imaging, late gadolinium enhancement (LGE) scanned by 5T can provide superior SNR and CNR, especially in the myocardium and pericardial fat, without affecting quantitative fibrosis assessment [5]. These findings support the clinical feasibility of 5T MRI for comprehensive cardiac evaluation, enabling clearer visualization of coronary anatomy, plaque, and fibrosis, and offering a non-invasive, radiation-free alternative for patients contraindicated for CCTA.

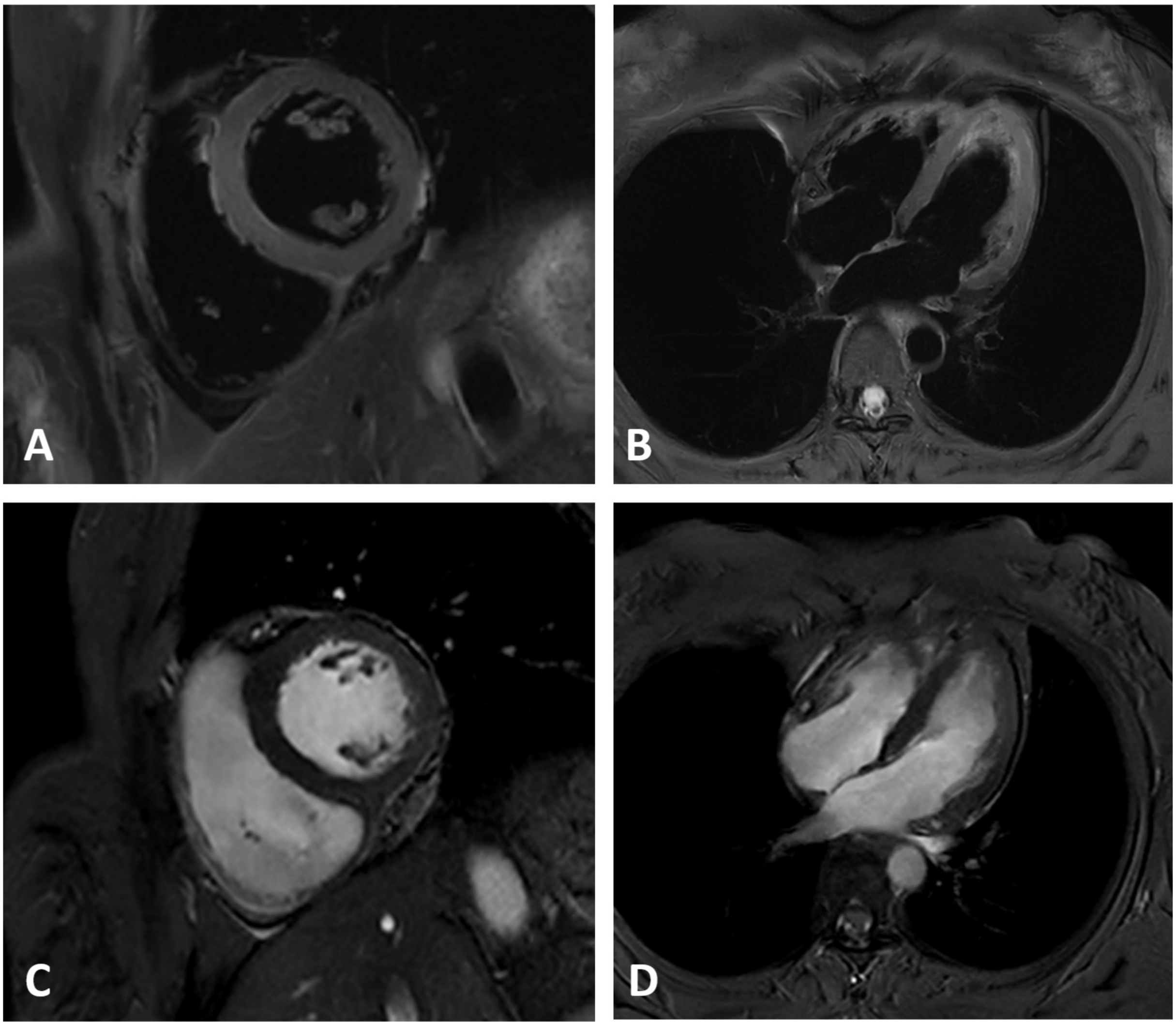


**Figure 2.** *High-resolution, non-contrast cardiac imaging sequences acquired at 5.0T: dark-blood images (A, B), cine images (C, D). Dark-blood images were acquired with a voxel size of 0.94 × 0.94 × 6 mm³ (A: short axis) and 0.83 × 0.83 × 6 mm³ (B: four-chamber), clearly delineating myocardial morphology at 5.0T. Cine images were acquired with a voxel size of 0.98 × 0.98 × 6 mm³ for both the short-axis (C) and four-chamber views (D).*

In abdominal imaging, recent studies have shown that 5.0T MRI offers clear advantages over 3.0T, particularly in terms of signal quality and small structure visualization. In pancreatic imaging, 5T DWI with reduced field-of-view provided a significantly higher signal-to-noise ratio and improved lesion conspicuity, without compromising ADC stability [5]. Similarly, in renal imaging, 5T MRI achieved better corticomedullary differentiation and clearer depiction of renal arteries and veins, with higher SNR and contrast ratios [6]. These results suggest that 5.0T MRI can enhance both structural and functional abdominal imaging, supporting its clinical potential beyond neuro and MSK applications.

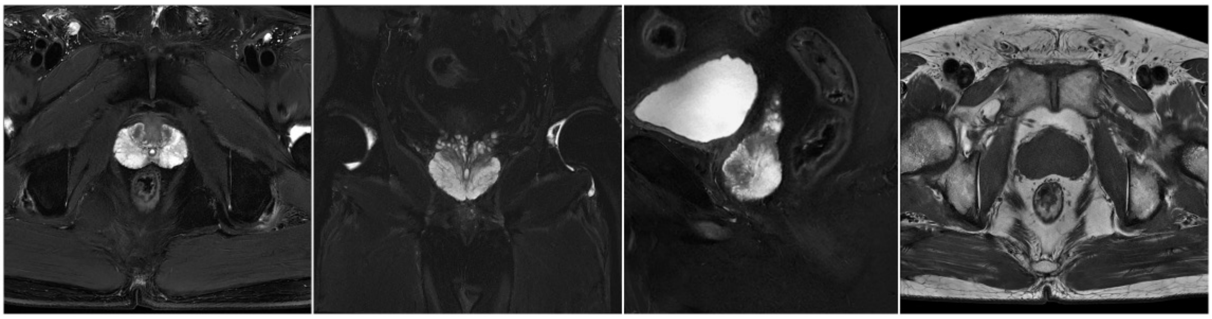

**Figure 3.** *High-resolution prostate imaging with 5.0T MRI, T2-weighted fat-suppressed FSE images in axial, coronal, and sagittal planes, and axial T1-weighted FSE (0.5 × 0.5 × 3 mm³); the fine internal structure and zonal anatomy of the prostate gland are clearly visualized.*

## Part IV. Establishing the Future of Ultra-high-field MRI

As a member of the Chinese Society of Magnetic Resonance Imaging in Medicine (CSMRM), I am pleased to share that the 5.0T MRI system has now been installed in over 35 hospitals across China. Leading institutions such as Fudan University Zhongshan Hospital, Peking Union Medical College Hospital, and the Shenzhen Institutes of Advanced Technology are actively exploring new clinical applications and technical innovations based on this platform.

With ongoing research, growing clinical evidence, and wider adoption, 5.0T MRI is poised to reshape diagnostic standards and support earlier, more precise detection across a wide range of whole-body applications.

We are deeply honored to play a part in this transformative journey and to help extend its clinical advantages to a larger number of patients in need. This milestone also reflects a wider trend: as the world's most populous continent, Asia is now playing an increasingly dynamic and proactive role in supporting the global progress in radiological innovation.

The future of ultra-high-field MRI is no longer a distant goal. It is already here.

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Perspectives

# Medico-legal responsibilities in radiological practice: A perspective on reducing risk

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**Keywords:** Artificial intelligence, Communication, Malpractice, Medical errors, Radiology, Risk Management.

## Introduction

Radiological interpretation is essential to patient care, yet it is inherently susceptible to error and miscommunication. Approximately 4% of all radiology reports contain errors, a statistic that underscores both the complexity of image interpretation and the medico-legal implications inherent in the practice of radiology. [1] This article offers a reflective analysis on radiologists' medico-legal challenges and practical strategies to reduce litigation risk and improve patient safety.

### Common Causes of Malpractice in Radiology

Malpractice claims in radiology stem primarily from diagnostic errors, procedural complications, and communication failures. [2] Among these, diagnostic error remains the leading cause, particularly in breast imaging, where missed or misinterpreted findings frequently result in delayed cancer diagnoses. Vascular injuries during interventional procedures also pose substantial medico-legal risks.

Although communication errors are less commonly cited in lawsuits, they often exacerbate clinical consequences and contribute to patient dissatisfaction. Thus, the medico-legal risk in radiology extends beyond technical accuracy and into interpersonal and institutional communication systems.

**Legal Framework and Accountability**

Depending on the jurisdiction and context, radiologists may be held liable under civil, criminal, or administrative law. [1, 2] Civil liability often arises from acts of negligence or a breach in the duty of care, while criminal liability may apply in cases of gross negligence or recklessness, particularly when harm results. In Thailand, specific laws govern medical liability and patient protection, including Section 402 of the Civil and Commercial Code and Section 59 of the Criminal Code. Awareness of these legal structures is essential for radiologists to protect themselves and reinforce professional responsibility and ensure informed clinical practice.

**Communication: A Pillar of Protection**

Failure to communicate effectively remains a persistent vulnerability in radiological practice. Incomplete reports, lack of recommendations for follow-up, and inadequate documentation of verbal discussions can all contribute to poor outcomes and potential litigation. Miscommunication is especially hazardous when delivering bad news, obtaining informed consent, or disclosing errors.

Radiologists must prioritize structured and comprehensive reporting that includes clinical context, findings, limitations, and a clear impression. Direct communication with referring physicians should be documented, particularly in urgent or ambiguous cases. In the digital era, this also means safeguarding patient confidentiality and securing imaging data through appropriate encryption and anonymization.

### Liability Insurance and Risk Mitigation

Professional indemnity insurance is an essential component of clinical radiology practice. It provides financial protection and promotes a culture of accountability and quality improvement. Beyond insurance, adherence to established guidelines and evidence-based protocols serves as a robust defense against claims.

Standardized communication practices, ongoing professional development, and the cultivation of a safety culture within departments can help reduce medico-legal risk.

### The Role of Artificial Intelligence (AI)

AI offers a promising adjunct in reducing human error and enhancing diagnostic precision. However, its integration also introduces new legal and ethical questions. Radiologists remain ultimately responsible for image interpretation, and AI should serve as a decision support tool rather than a substitute. Transparency in AI deployment, algorithm validation, and documentation of its role in clinical decision-making will be vital to maintaining professional standards and legal defensibility.

## Conclusion

Radiologists operate at a critical intersection of technology, clinical medicine, and patient care. As such, they carry significant responsibility for accurate image interpretation, effective communication of findings, ethical engagement, and the protection patient rights. By understanding the medico-legal landscape and actively adopting risk-reduction strategies, radiologists can safeguard their patients and professional integrity.

## Lessons Learned

The intersection of radiology and the law reveals that clinical excellence alone does not mitigate medico-legal risk. Highly competent radiologists may face litigation due to systemic failures, ineffective communication, or insufficient documentation. One of the most valuable lessons is the importance of proactive risk awareness—not waiting for adverse events to highlight vulnerabilities.

Another key insight is that miscommunication is not always negligence, but oversight—whether in failing to relay incidental findings, omitting recommendations, or underestimating the value of direct dialogue with referring physicians. Additionally, the emotional and financial toll of litigation serves as a reminder of the need for institutional support systems, including mentorship, legal counsel, and structured peer review.

## Practical Recommendations

1. Implement structured reporting that includes clinical context, relevant comparisons, clear impressions, and limitations. This enhances clarity and reduces ambiguity in interpretation.
2. Document all verbal communications with referring physicians, especially for critical or unexpected findings. Brief notes in the report or within the PACS system can serve as vital records.
3. Improve informed consent processes for interventional procedures, ensuring patients understand risks, benefits, and alternatives.
4. Participate in multidisciplinary meetings to strengthen communication channels and enhance collaborative decision-making.
5. Invest in regular medico-legal training and continuing education in risk management, especially related to emerging technologies like AI.
6. Promote a culture of safety and openness where errors can be disclosed, analyzed, and learned from without fear of retribution.
7. Ensure adequate liability insurance is in place, and review coverage regularly in light of evolving practice patterns.
8. Respect digital confidentiality protocols, including the anonymization of teaching images and the encryption of sensitive data.

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ASEAN Movement in Radiology

# The 1st International Radiology Resident Quiz in the 23rd Asian Oceanian Congress of Radiology (AOCR) 2025

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## Abstract

The 23rd Asian Oceanian Congress of Radiology (AOCR) 2025 was held from January 23-26, 2025, at the Chennai Trade Center in Chennai, India, attracting over 6,000 delegates from 47 countries. Organized by the Tamilnadu and Pondicherry Chapter of the Indian Radiological and Imaging Association (IRIA) in collaboration with the Asian Oceanian Society of Radiology (AOSR), the congress featured a comprehensive scientific program with plenary sessions, workshops, scientific presentations, and specialized symposia.

A significant highlight was the First International Radiology Resident Quiz, with participation from 20 countries. India won first place, Thailand secured second, and the UK placed third. The quiz, designed to challenge participants with complex radiology cases, included semifinals with multiple-choice questions and a final round conducted live on stage.

The event also introduced innovative concepts such as "Silent Halls," where simultaneous sessions were delivered via headphones, enhancing session management and participant engagement. Additionally, the Arokia Radiology Clinic provided on-site health check-ups, which were attended by over 700 delegates.

Cultural and social events, including traditional performances, themed dinners, and a gala night at VGP Golden Beach Resort, enriched the delegates' experience. Prominent exhibitors included United Imaging, Siemens Healthineers, GE Healthcare, Philips, Fujifilm, Canon, and Bayer, alongside international radiological societies. Overall, AOCR 2025 successfully promoted global collaboration, education, and cultural exchange among radiology professionals.

**Keywords:** Asian Oceanian Congress of Radiology (AOCR), Chennai, India, International Radiology Resident Quiz.

## General information of AOCR 2025

1. Date and Time of the Event
   The congress from January 23 to January 26, 2025. The opening ceremony took place on January 23, and the sessions and events continued until January 26. The social programs and gala dinners also occurred during these dates.

2. Venue and Location (Including City and Country)
   All live sessions and events took place at the Chennai Trade Center in Chennai, India. Chennai is located in the state of Tamil Nadu, on India's southeastern coast.


*A daily showcase in front of at the Chennai Trade Center.*

3. Organizers and Host Institutions
   - Organized by the Tamilnadu and Pondicherry Chapter of the Indian Radiological and Imaging Association (IRIA), under the auspices of IRIA.
   - Dr. Amarnath Chellathurai served as the organizing chairman.
   - Dr. L. Murali Krishna served as the organizing secretary.
   - The congress was held in collaboration with the Asian Oceanian Society of Radiology (AOSR), led by AOSR's president, Dr. Noriyuki Tomiyama, and IRIA's president, Dr. V.N. Varaprasad.

4. Total Number of Participants or Attendees
   - More than 6000 delegates attended from 47 different countries.
   - Official statistics indicate 5491 registered delegates, 616 trade exhibitors, and 649 radiographers, resulting in a combined total of 6756 attendees.

5. Companies or Organizations Exhibiting at the Event
   Approximately 100 companies participated in the massive technological exhibition. The key industrial supporters included:
   - United Imaging
   - Siemens Healthineers
   - GE Healthcare
   - Fujifilm
   - Canon
   - Allengers

Additionally, booths were featured from international radiological societies and Indian subspecialty associations under FORA (Federation of Radiological Associations).


*The presidents and committee members of the Royal College of Radiologists and Radiological Society of Thailand at their booth at AOCR2025.*

6. Main Content or Sections of the Event
    - Scientific Program: Featured orations, plenary sessions, scientific paper presentations, poster sessions, and special joint symposia with international radiology societies.

    - Workshops: Twenty workshops covering ultrasonography, CT/MR advancements, interventional radiology, AI in radiology, etc.

    - Quizzes and Contests: Inaugural International Radiology Resident Quiz with 20 participating countries, along with activities such as “Case of the Day,” “Diagnosis challenge,” art and photography competitions, and an escape-room style radiology puzzle.

    - Business and Leadership Meetings: Included the 10th Asian Oceanian Radiological Forum (AORF), International Radiology Forum (IRF), and various leadership sessions among radiological societies.


*The meeting between the presidents and the committee members of the Royal College of Radiologists of England, the Royal College of Radiologists of Thailand, and the Radiological Society of Thailand at AOCR2025.*

- Technological Exhibition: Showcasing the latest advancements in imaging and interventional technology, along with a special exhibit for radiology equipment and historical artifacts.

- Social and Cultural Events: Daily luncheons with live music, themed dinners, cultural performances (e.g., Bharatanatyam dance), and a gala night at VGP Golden Beach Resort featuring fireworks and a drone light show.


*The current presidents of the Royal College of Radiologists of Thailand (RCRT) and Radiological Society of Thailand (RST) congratulate Dr. Chamaree Chuapetchara-sopon, the former RST president, on her handing over AOSR president during 2025-2027.*


*Cultural events at AOCR2025.*

7. Impressive or Highlighted Content from the Program
   - Opening Ceremony with "Xtron" Robot: Demonstrated technological innovation in medical imaging.
   - Notable Lectures and Plenaries: Key addresses by Prof. Andrea G. Rockall, Dr. Jeong Ming Lee, Prof. Anil Ahuja, Dr. Mathew Cherian, and other eminent faculty.
   - "Silent Halls" Concept: As multiple sessions were held in the same main hall, speakers were not utilizable. Instead, all attendees were handed a pair of headphones with a remote control, specifically for each session. Here, the speakers gave lectures via the microphone which was recorded and transmitted directly into the participants' headphones. This novel method was effective for arranging multiple simultaneous sessions within the same room.


- The First International Radiology Resident Quiz: India won first prize, Thailand second, and the UK third, creating a new benchmark in global radiology education.


*The representatives from Thai radiological residents participated and received the second prize at The First International Radiology Resident Quiz.*

- AOCR Gala Night: Hosted at VGP Golden Beach Resort, concluded with a drone light show, fireworks, and a concert by celebrity singer Neeti Mohan under the neon night theme.

- Arokia Radiology Clinic: A novel on-site health checkup initiative for delegates (ultrasonography of abdomen and breast, fibroscan, echocardiography, blood workups), attended by over 700 participants.


*The Arokia Radiology Clinic at AOCR2025*

## International quiz

Apart from the lectures and workshops, a new event has emerged for both academic and entertainment purposes, the "International Radiology Quiz", the first of its kind. Each country was required to send 2 radiology residents to answer radiology-related quizzes. From Tokyo to London, participants from 20 countries from Asia and Europe eagerly participated. The International Radiology Quiz consisted of 2 rounds, the semifinal and the final, the latter in which only the top 6 teams qualified to compete. The semifinal round began with multiple-choice questions, while the final round was conducted on stage. Here, the participants from each country took turns cracking difficult cases and showcasing their expertise to the audience. Thailand had the opportunity to advance into the final round and won the 1st runner up prize.

*The atmosphere of the final round of The First International Radiology Resident Quiz*

**Experience gained from the quiz and the AOCR**

The competition had, in fact, taken place several weeks prior to the main event, as the organizers kept us occupied with daily case quizzes to warm up our engines. Many cases in both the semifinal and the final rounds were designed to stimulate our maximum adrenaline rush, which they succeeded in doing. Due to both the complexity of the cases and the competitive environment, contestants and the audience alike might have found it hard to sit still. These factors, however, undoubtedly pushed our limits to use our wits and wisdom. Interestingly, many quiz cases were a wonder to behold, such as rare diseases and advanced modalities. As radiologists usually learn by vision, seeing as many interesting cases as possible would add valuable knowledge to our arsenal. Moreover, this event provided a glimpse of the radiology societies on a global scale and provided a great opportunity for all attendees to broaden their perspectives and amplify sources of inspiration.

During the period of 4 days in the AOCR 2025, friendships were forged, and many cultural activities were greatly appreciated. India and the city of Chennai were among the most spectacular places we have visited so far. Tamil cuisine, traditional performances and the religious attractions are a unique ensemble of great experiences. Thanks to the organizing committees and all associated societies, we returned to Thailand with not only newfound knowledge, but also fond memories of our unforgettable time.

## Conclusion

The International Radiology Resident Quiz in the 23$^{rd}$ Asian Oceanian Congress of Radiology (AOCR) 2025 proved to be a valuable activity complementing existing activities including poster and oral presentations to promote relationships among international radiological residents and to introduce AOSR and AOCR to the younger generations.

ASEAN Movement in Radiology

# What we have learned from the session "Malaysia-Thailand Collaboration on DRL: Moving Forward" in the Malaysian Congress of Radiology Meeting 2024

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## Abstract

The session highlighted the collaborative efforts between Malaysia and Thailand in optimizing diagnostic reference levels (DRLs) for radiation exposure in medical imaging. The councils also emphasized the differences in approach: Malaysia's top-down mandatory system versus Thailand's voluntary cooperation model. Challenges such as funding, protocol establishment, and training were identified as barriers to effective DRL implementation. The importance of collaboration among radiologists, medical physicists, and technology developers was stressed to enhance patient safety and optimize radiation doses. Future strategies proposed included developing updated guidelines, sharing anonymized dose data, and organizing workshops to foster knowledge exchange. The session concluded with a call for legislative support in Thailand to make national dose surveys mandatory, aiming for improved radiation safety standards in both countries.

**Keywords:** Diagnostic reference levels, Malaysia, National DRLs, Radiation dose, Thailand.

The meeting was held on 27 July 2024 in Kaula Lumpur, Malaysia. The panelists were Professor Dr. Norzaini Rose Mohd Zain (Head of Radiological Service of Malaysia), Professor Dr. Norlisah Mohd Ramli (Present President of Malaysian Congress of Radiology, MCOR), Professor Dr. Kartini Rahmat (Organizing Chair), Associate Professor Dr Farhana Fadzli (Scientific Chair), Mdm Nurmazaina Md Ariffin, MMedPhys (Senior Principal Assistant Director Medical Radiation Surveillance Division, Ministry of Health), Professor Kwan Hoong Ng, PhD (Department of Biomedical Imaging, Faculty of Medicine Universiti Malaya (UM) and Supika Kritsaneepaiboon, M.D in the representative of Radiological Society of Thailand (RST).

The first dose survey in Malaysia was initiated in 1993-1995 including only 12 public hospitals and reported in United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000. The first national dose survey was conducted by the Ministry of Health, Malaysia in 2007-2011 covering diagnostic and interventional radiology, nuclear medicine and dental radiology. It was conducted in 437 public and private hospitals, medical centers or GP clinics, and 329 public and private dental hospitals. Whereas the first dose survey in Thailand was initiated in 2017 and first reported in 2018 which was conducted only with general and dental radiography. It was obtained only from 250 X-ray machines in the total of 6189 machines including from public and private hospitals and medical centers. A potential source of bias may arise from the use of different types of machines between urban and rural areas. The national dose survey in Malaysia is under the control of the Medical Radiation Surveillance Division, Ministry of Health and it is the top-down approach. The hospital recruitment and dose survey are regulated and mandatory. On the contrary, the dose survey in Thailand is voluntary and manipulated from the cooperation of many organizations.

The diagnostic reference levels (DRLs) were introduced by the International Commission on Radiological Protection (ICRP) in ICRP publication 73 to improve CT dose optimization by identifying unjustified levels of radiation doses [1, 2]. The department of Medical Science, Ministry of Public Health is principally responsible for the main responsibility for the National Diagnostic Reference Levels

(DRLs) in Thailand. The other dose surveys of CT, interventional and cardiovascular X-ray machines are also conducted to and supported by the Royal College of Radiology of Thailand (RCRT), the Office of Atoms for Peace, the Thai Society of Vascular and Interventional Radiology (TSVIR) and the Cardiovascular Intervention Associated of Thailand. For example, the Projects THA6043 supported by the Office of Atoms for Peace conducted the CT dose survey in both adults and children. Although the hospital recruitment from more specific professional organizations (e.g. RCRT, or TSVIR) had a smaller number of hospitals (25-30 hospitals), they could provide more specific details of the study, for example, computed tomographic angiography (CTA) of coronary in prospective and retrospective electrocardiogram (ECG) gating; CTA of aorta categorized in whole aorta, thoracic aorta, and abdominal aorta; CTA for stroke fast track categorized into brain in 3 phases, brain and neck in 1 phase; and CT for urinary stone categorized into single energy and dual energy. Thailand also conducted National CT dose index registry reported by the Office of Atoms for Peace and The Royal College of Radiology of Thailand (RCRT) in which the CT protocol names were categorized into body regions and non-contrast and contrast studies regarding to the American College of Radiology's Dose Index Registry. After the other organizations complete their dose survey, they will report back to the Ministry of Public Health. It is like a bottom-top approach which is different from the Malaysian system. We suggested the Ministry of Public Health in Thailand cooperate with radiologists who deal with radiation optimization and national DRLs in the representatives of public/ government hospitals, private hospitals, and medical school hospitals and legislate the National Dose Survey as a mandatory or legally bound to obtain more recruited hospitals, which resembles the Malaysian models.

Lack of funding for support, protocol establishment and training to understand DRL were the main common constraints for pre-implementation of the DRL. The limitations during data collection were manpower, variable machine technologies, and human errors. The post-implementation limitations lied with clinical practice and standardized protocols. We tried to encourage the DRL implementation without penalties for those whose radiation dose exceeds the DRL. The radiographers and technologists should understand how to implement DRLs into clinical practice. Furthermore, the medical physicists can help adjust image parameters and radiologists can help by providing clinical image quality requirements, particularly the CT images. Most radiologists are not familiar with the grainy image (high image noise), which can be solved by using image reconstruction software or deep learning image reconstruction. Iterative Reconstruction in Image Space [IRIS], Sinogram-Affirmed Iterative Reconstruction [SAFIRE], and Advanced Model-Based Iterative Reconstruction [ADMIRE], Siemens Healthcare; iDose and Iterative Model Reconstruction [IMR], Philips Healthcare; Adaptive Statistical Iterative Reconstruction [ASIR] and Model-Based Iterative Reconstruction [MBIR or Veo], GE Healthcare; and Adaptive Iterative Dose Reduction [AIDR], Cannon Medical Systems, have all demonstrated the potential to reduce radiation dose on various scanners [3]. Additionally, the U.S. Food and Drug Administration (FDA) has approved three CT vendors' deep learning algorithms for commercial use: TrueFidelity (GE Healthcare), AiCE (Canon Medical Systems), and Precise Image (Philips Healthcare) [4].

The reported DRL for plain radiographs between Thailand (2021) and Malaysia (2013) is presented in Table 1. One limitation is that we could not directly compare the reported Diagnostic Reference Levels (DRLs) between Thailand and Malaysia due to differences in radiographic techniques and measurement units. Thailand used digital radiography (DR) and reported patient dose in terms of entrance-surface air kerma (ESAK), while Malaysia used computed radiography (CR) and reported dose as entrance surface dose (ESD). ESAK measures the energy transferred to the skin surface during an X-ray procedure, whereas ESD represents the actual radiation dose absorbed by the patient’s skin. In DR, ESAK is commonly used to evaluate patient exposure, while ESD is widely applied in both CR and DR. Both metrics are essential for optimizing the radiation dose while preserving the image quality.

The comparison of DRL for CT study between Thailand (2023) and Malaysia (preliminary report in 2024) is presented in Table 2.

Dual-energy CT (DECT) can provide certain patients benefits even when using lower radiation doses and less cancer risk compared to traditional single-energy CT (SECT), primarily due to improved image quality, material differentiation, and diagnostic efficiency. Moreover, it can provide more image information such as types of urinary stone and areas of decreased pulmonary perfusion or infarcts. The DRL of multiphase abdominal CT study was higher than that of Malaysia could be due to the multiphase study, including the delayed phase in Thailand.

There are several strategies and actions that Thailand and Malaysia could implement in the future to advance the field and improve patient safety. Firstly, guidelines that reflect the latest research and technological advancements can be developed and updated. The work can done be toward the protocol standardization across different regions and institutions. Secondly, anonymized dose data can be shared across institutions to build comprehensive databases, which can serve as collaborative research. Thirdly, relevant parties can organize or participate in workshops and conferences focused on DRLs, where professionals can share knowledge, experiences, and advancements. Lastly, there can be a collaboration with technology developers to develop new software tools or systems that can assist in dose data analysis.

**Table 1.** *The reported DRL for plain radiographs between Thailand (2021 and 2023) and Malaysia (2013) [5-7].*

| | | Thailand (2021)* ESAK (mGy) | Thailand (2023)* ESAK (mGy) | Malaysia (2013)† ESD (mGy) |
|---|---|---|---|---|
| **Examination Type** | Projection | | | |
| **Chest** | PA | 0.3 | 0.4 | 0.87 |
| **Abdomen** | AP | 3.8 | 3.49 | 7.36 |
| **Pelvis** | AP | 3.1 | 3.15 | 5.80 |
| **Cervical** | AP | - ‡ | 1.39 | 2.10 |
| | Lateral | - ‡ | 1.36 | 2.05 |
| **Thoracic** | AP | - ‡ | 3.74 | 6.80 |
| | Lateral | - ‡ | 5.81 | 7.50 |
| **Lumbo-sacral** | AP | 3.8 | 3.4 | 7.50 |
| | Lateral | 9.8 | 9.18 | 13.4 |
| **Skull** | AP | 2.6 | 2.28 | 4.80 |
| | Lateral | 2.1 | 2.09 | 2.40 |

*Note: *Data obtained from Digital Radiography, † Data obtained from computed radiography (CR) ‡ Uncollected data, and, ESAK = entrance-surface air kerma, ESD = entrance surface dose.*

We were unable to compare the reported DRL between two countries because of different obtained radiographic techniques and different measured quality units.

**Table 2.** *The comparison of DRL (DLP unit mGy*cm) for CT study between Thailand (2018-2023) and Malaysia (preliminary report in 2024) [6, 8].*

| Examination Type | Thailand DMSc (2018) | Thailand THA6043 (2018) | Thai RCRT and OAFP (2021-2022) | Thai CT-DR 9 hospitals (2023) (P75) | Malaysia (2024) |
|---|---|---|---|---|---|
| **Brain, single phase** | 935 (C)<br>1028 (NC) | 1166 (C)<br>1125 (NC) | - | 1157 (NC) | 960 |
| **Chest** | 655 (C)<br>417 (NC) | 509<br>(C or NC) | - | 451 (C)<br>452 (NC) | 310<br>(routine) |
| **Abdomen 1 phase with contrast** | 717 | 741 | - | 932 | 810 |
| **Abdomen Multi-phases** | - | 2307 | - | 2239 | 1350 |
| **Thorax & abdomen (one phase)** | - | 1001 | - | 1179 | 820 |
| **CT renal stone** | - | - | 625 (single energy)<br>544 (dual energy) | - | 500 |
| **CTA coronary** | - | - | 233 (pro)<br>976 (retro) | - | 860 (pro) |
| **CTA brain** | - | - | 1095 | - | 1500 |
| **CT pulmonary angiogram** | | | 495 (single energy)<br>304 (dual energy) | | 300 |
| **Neck** | | | 504 | | 400 |
| Paranasal sinus | | | 548 | | 430 |

*Note: Abbreviation C = contrast study, NC = non-contrast study, DMSc = Department of Medical Science, RCRT = Royal College of Radiology Thailand, OAFP = Office of Atoms for Peace, Pro = Prospective EKG gating, Retro = retrospective EKG gating.*

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