Cardiovascular Examination with 3.0 Tesla Magnetic Resonance Imaging: First 100 Cases at Ramathibodi Hospital

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Background: *Cardiovascular magnetic resonance imaging (CMR) has been utilized for diagnosis in various cardiovascular diseases and most of those were performed on a 1.5 Tesla CMR system. Recently, a 3.0 Tesla magnetic resonance imaging system has been introduced into clinical practice, however, the clinical experience on cardiovascular examination using this system is limited. Therefore, the authors' institution has integrated a team for developing a CMR program on this 3.0 Tesla system.*
Objective: *To describe the authors' experience on the 3.0 Tesla CMR system.*
Material and Method: *The data on patients referred to the authors' CMR unit between August 2004 and October 2005 were reviewed.*
Results: *One hundred patients were referred for CMR examination. The mean age was 56 years (2 month - 85 years) and 65 patients were male. The most common indication was to assess coronary artery disease (64 patients). The performed examination was divided into cardiac structure and function assessment (39%), stress testing (23%), coronary magnetic resonance angiography (13%), myocardial viability assessment (12%), magnetic resonance angiography (9%), and flow assessment (4%).*
Conclusion: *The present study highlights that comprehensive assessment of various cardiovascular diseases can be performed on the 3.0 Tesla CMR system.*

Keywords: *Magnetic resonance imaging, Cardiovascular disease, Congenital heart disease, Coronary artery disease, Vascular disease*

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Cardiovascular magnetic resonance imaging (CMR) has been utilized for diagnosis of various diseases in cardiovascular medicine including coronary artery disease, myocardial disease, pericardial disease, congenital heart disease, vascular disease, etc(1). Most CMR examinations were performed on a 1.5 Tesla magnet system, which is now a robust tool for cardiovascular assessment due to excellent spatial resolution, its lack of radiation exposure, and the comprehensive information being provided. Recently, a 3.0 Tesla magnetic resonance imaging system was introduced to clinical practices with the expectation of improved imaging signals and shorter scanning time in some applications(2-5). However, the experience on cardiovascular examination with a 3.0 Tesla CMR is limited and available in very few sites worldwide. The authors' institution was the first in Thailand utilizing a 3.0 Tesla CMR in clinical practice and extended the applications for cardiovascular examination. To have a successful CMR program, the authors have integrated the CMR team that con-

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sists of groups of cardiologists, radiologists, anesthesiologists, technicians, and nursing staff.

The objective of this report was to share the authors' experience of a 3.0 Tesla CMR program used on the first 100 consecutive patients.

Material and Method

The authors have reviewed 100 consecutive cases referred to the imaging center at Ramathibodi Hospital, Mahidol University for CMR examination with the 3.0 Tesla magnetic resonance scanner (Philips Medical System, Best, Netherlands) between August 2004 and October 2005. The demographic data, type of studies, indications of CMR studies were reviewed. The data was presented in descriptive manner and appropriate graphics were demonstrated in this manuscript.

Results

The present review consisted of 100 patients with an average age of 56 years (2 months - 85 years), 65 male, and 95 adults (age > 14 years). The CMR study duration was between 30-90 minutes and no complications were reported. The indications are shown in Table 1.

Table 1. Indications for patients referred for cardiovascular magnetic resonance imaging at Ramathibodi Hospital between August 2004 and October 2005 (n = 100)

Indications (To assess or rule out)	Patients (n)
Coronary artery disease	64
Congenital heart disease	13
Right ventricular dysplasia	6
Disease of the aorta	4
Valvular heart disease	3
Constrictive pericarditis	3
Cardiomyopathy	2
Pulmonary hypertension	2
Marfan syndrome	1
Cardiac mass	1
Coronary artery aneurysm	1

The most common indication was to assess coronary artery disease. Stress tests were performed with either dipyridamole (51 patients) or adenosine (4 patients) stress CMR (Fig. 1). All patients tolerated the procedures well without serious complications. Only 2 patients were found to have ischemic electrocardiographic changes during recovery and required sublingual nitroglycerine to normalize it. Coronary magnetic resonance angiography (MRA) was performed in 30 patients and provided information on proximal and mid segments of the coronary arteries (Fig. 2). Twenty-eight patients were assessed for myocardial viability where the authors utilized delayed hyperenhancement imaging after Gadolinium - based contrast administra-

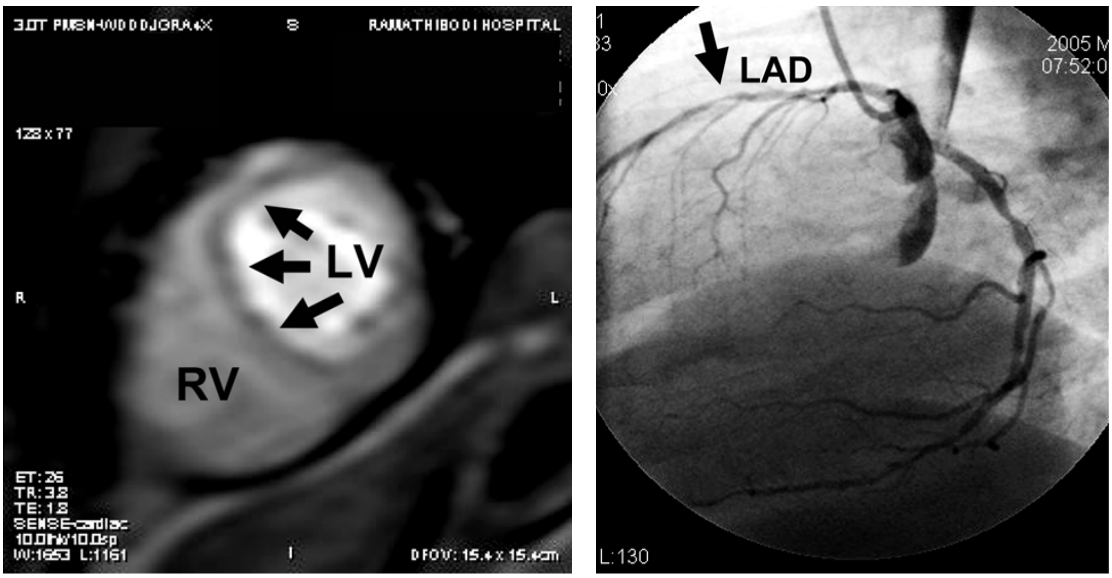

Fig. 1 First pass images during Gadolinium bolus of the left ventricle in short axis view after dipyridamode administration demonstrated the area of hypoenhancement (arrows) in the anterior, anteroseptum, and septum walls consistent with subendocardial ischemia in the left anterior drscending coronary artery (LAD) distribution (left). The patient underwent coronary angiography which revealed severe stenosis of the LAD (right)

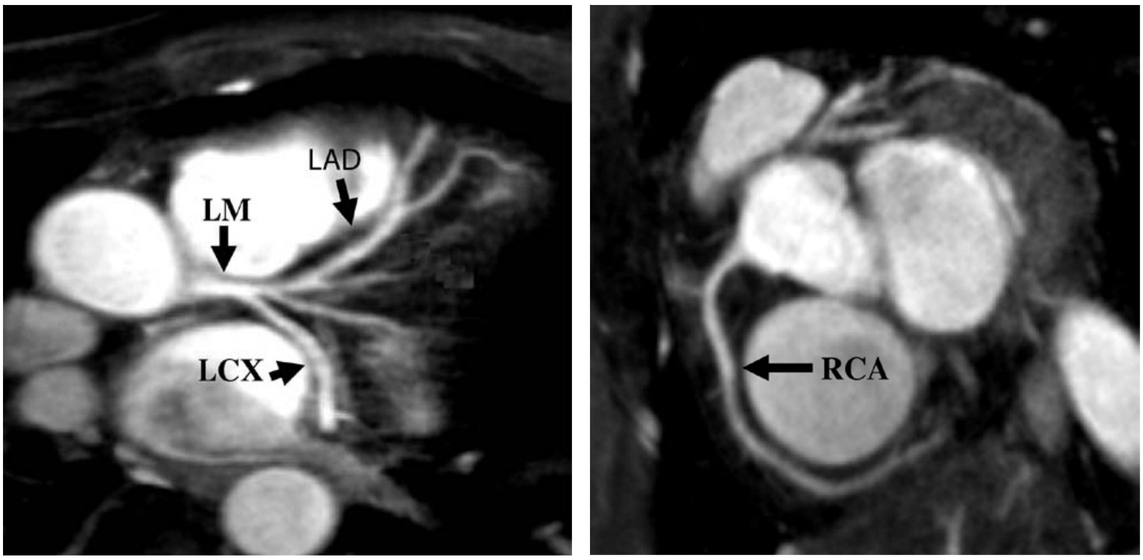

Fig. 2 Reconstructed images of coronary magnetic resonance angiography are displayed. The left coronary artery system and right coronary artery displayed on the left and right panels, respectively. LAD = left anterior descending artery, LM = left main, LCX = left circumflex artery, and RCA = right coronary artery)

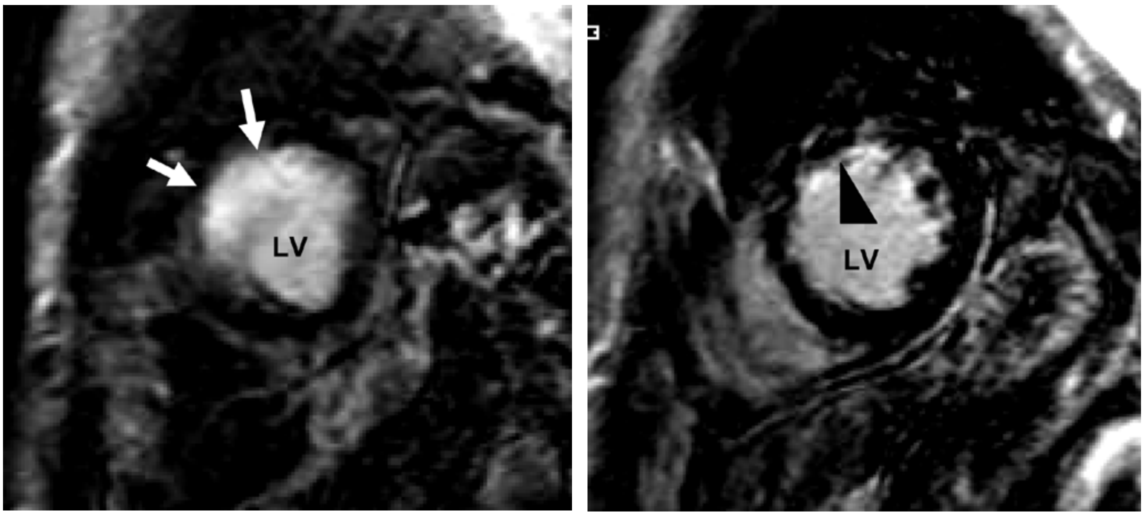

Fig. 3 Delayed hyperenhancement images of the ventricle display in apical (left panel) and mid (right panel) short views. Transmural myocardial infarction reveal as hyperenhanced area at the septum and anterior walls of apex (arrows). Subendocardial infarction is shown at mid anterior wall (arrow head) (LV = left ventricle)

tion to determine myocardial scar tissue (Fig. 3). Other indications were congenital heart diseases (13 patients) (Fig. 4), right ventricular dysplasia (6 patients), disease of the aorta (4 patients), and others (13 patients).

The types of CMR examinations to answer clinical questions are shown in Fig. 5.

Discussion

This report has shown that various cardiovascular diseases can be assessed with a 3.0 Tesla CMR. With the software and hardware development, the authors could perform all necessary scanning sequences to answer the clinical questions.

Coronary artery disease

Dipyridamole or adenosine stress perfusion CMR has been studied extensively in the 1.5 Tesla system and the sensitivity and specificity for detecting

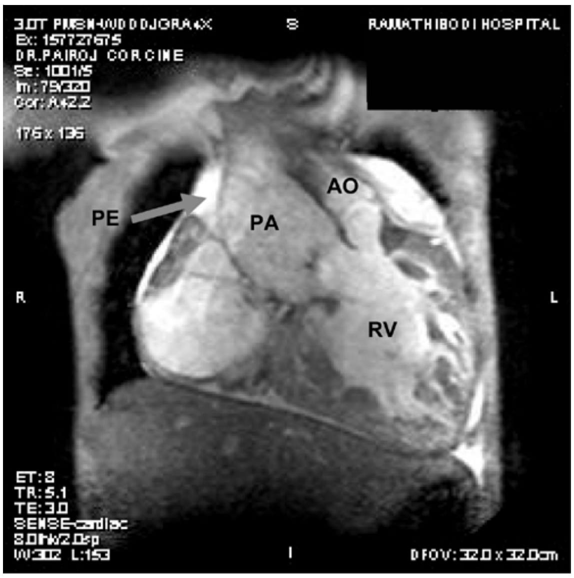

Fig. 4 The cine gradient echo image of the heart in coronal planes demonstrates dilated right ventricle. Pulmonary artery and aorta come off the right ventricle and there is circumferential pericardial effusion (arrow). (AO = aorta, PA = pulmonary artery, PE = pericardial effusion, RV = right ventricle)

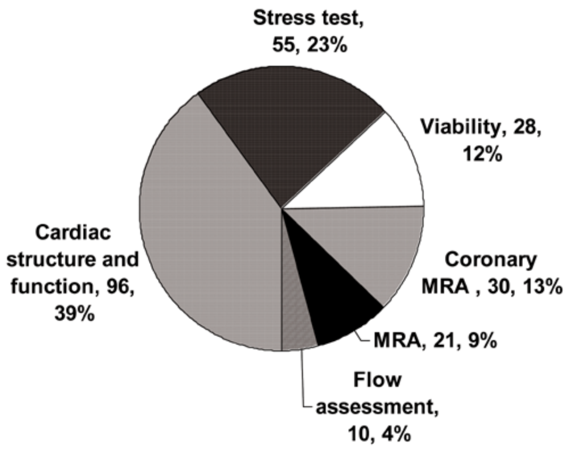

Fig. 5 This graph displays the distribution of types of cardiovascular magnetic resonance imaging examinations

coronary arterial luminal narrowing more than 50% are both in the range of 80-90% compared to conventional coronary angiography in those studies[6-10]. The present study is showing that it is feasible to detect inducible ischemia on the 3.0 Tesla CMR system and its resolution allows the ability to detect the variable degrees of subendocardial ischemia. To perform a stress MR perfusion study, the safety measures, including emergency carts and continuous vital signs monitoring, are required. Pre and post electrocardiography is needed to ensure the patient's safety. The attractive feature of this test is that physicians can interpret and report the result as soon as the scan is completed due to real-time imaging reconstruction.

With the increased signal to noise and contrast to noise in the 3.0 Tesla system, it has shown promising data in coronary MRA[2,11,12]. The authors have utilized the CMR to examine the presence of coronary arterial luminal narrowing and congenital anomaly of coronary arteries. Further development will improve the utility of coronary MRA with 3.0 Tesla CMR.

Several parameters from CMR can be utilized to determine myocardial viability in cardiac patients and the most practical and easy technique to perform is contrast-enhanced CMR with delayed hyperenhancement imaging. The extent of myocardial scar has been correlated with functional recovery post coronary revascularization, contractile reserve during dobutamine administration, and histology[13-16].

Therefore, CMR can provide comprehensive assessment of coronary artery disease and the study can be accomplished within 40-60 minutes as shown in the diagram (Fig. 6).

Congenital heart disease

Complex congenital heart disease is a frequent encountered situation for cardiologists and CMR has increased its role in the evaluation of complex congenital hearts. Due to large field of view and no limitation in imaging acquisition planes, 3-dimension related information from CMR can help clinicians and surgeons in treatment planning[17-21]. The excellent structural and functional information in interested structure helps clinician to assess the shunt ratio, blood flow to pulmonary artery and great vessels, and valvular function. Often CMR has been utilized to follow post congenital heart surgery to examine right and left ventricular function, shunt status, and residual lesions.

Right ventricular dysplasia

Right ventricular dysplasia is characterized by the fatty infiltration of the right ventricular wall. Criteria to diagnose this condition depend on electrical, structural, or functional abnormalities resulting from the loss of right ventricular myocytes. Noninvasive assessment has been utilized for the detection of this condition and CMR is a frequently utilized modality because it provides simultaneous information on structure, tissue characterization, and function of the right ventricle[22,23].

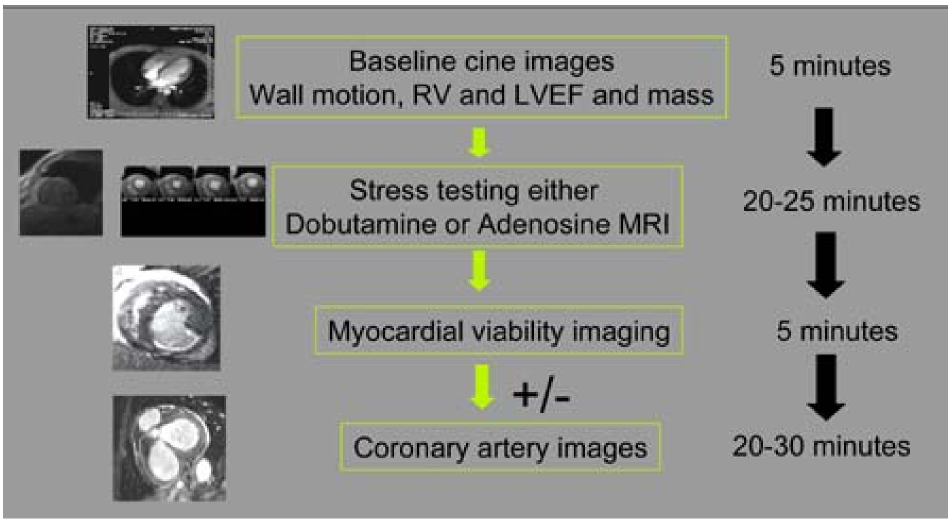

Fig. 6 Diagram of utilization of cardiovascular MRI as one stop shop for coronary artery disease assessment

Magnetic resonance angiography

Magnetic resonance angiography can be performed in the 3.0 Tesla CMR with higher signal to noise and contrast to noise than the 1.5 Tesla system[12,24,25]. Therefore, whole body MRA can be performed during Gadolinium-based contrast administration with excellent spatial resolution. MRA of renal arteries can be utilized to assess renal artery stenosis in patients with uncontrolled hypertension and impaired renal function. The authors have performed screening abdominal aortic aneurysm, which can be found as a concomitant condition in atherosclerotic patients, with or without contrast administration (Fig. 7). One of the patients sent to exclude patent ductus arteriosus that cannot be visualized in routine structural and functional imaging, but was demonstrated clearly in MRA of the thoracic aorta (Fig. 8).

Pericardial disease

Pericardial thickness can be examined with CMR and it has been noted that thickness > 4 mm is considered to be abnormal. Constrictive pericarditis is often a difficult clinical syndrome to diagnose. CMR can provide information on pericardial thickness and functional information to differentiate this condition from restrictive cardiomyopathy. Pericardial effusion either

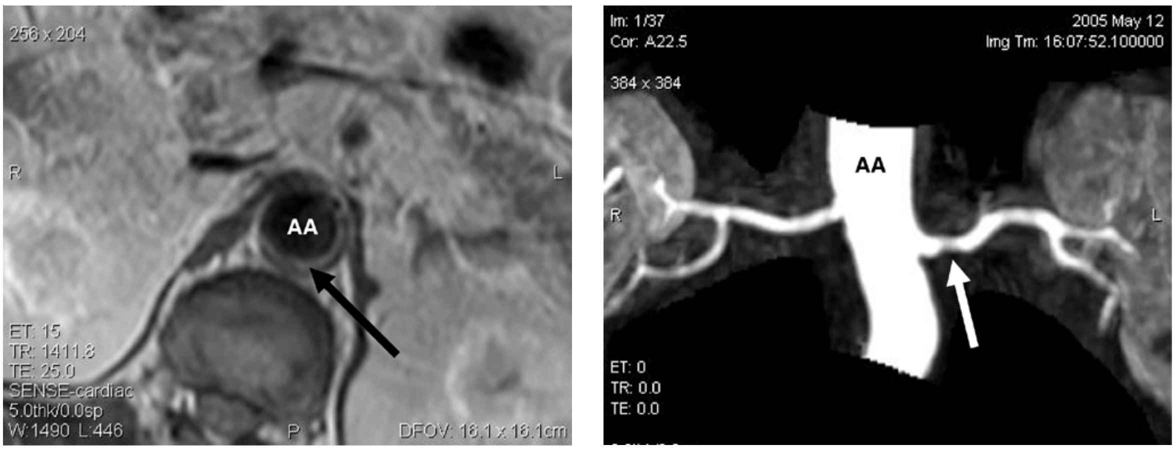

Fig. 7 Black-blood image of the abdominal aorta displays in cross-section (left panel) and there is the atherosclerotic plaques visualized (black arrow). Renal magnetic resonance angiography (right panel) reveals mild luminal narrowing of the left renal artery (white arrow)

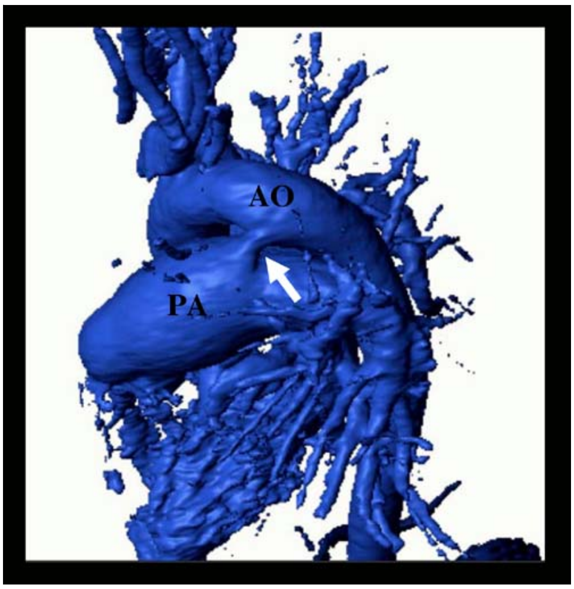

Fig. 8 Magnetic resonance angiography of the great vessels displays the patent ductus arteriosus (arrow) connecting between aorta and pulmonary artery (AO = aorta, PA = pulmonary artery)

localized or circumferential type can be assessed[26-28].

Valvular heart disease

In addition to valvular structural assessment, CMR can assess the severity of stenotic or regurgitant lesion. The blood flow or volume of the left ventricle, aorta, or pulmonary artery can be accurately assessed by volume measurement or phase-contrast velocity encoded method[29-31].

Conclusion

The present study highlights that the 3.0 Tesla CMR can be utilized as a tool for assessing various cardiovascular conditions in cardiology practices.

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การตรวจหัวใจและหลอดเลือดด้วยเครื่อง 3.0 T MRI: ประสบการณ์ในผู้ป่วย 100 คนแรกที่โรงพยาบาลรามาธิบดี

ไพโรจน์ ฤกษ์พัฒนาพิพัฒน์, สุวิภาภรณ์ ศิริพรพิทักษ์, รัตนพร พรกุล, สุทธิพงษ์ จงจิระศิริ, จิรพร เหล่าธรรมทัศน์

ที่มา*: การตรวจวินิจฉัยโรคหัวใจต่างๆ สามารถตรวจได้ด้วยเครื่อง 1.5 Tesla cardiovascular magnetic resonance imaging (CMR) ถึงแม้ว่า ได้มีการนำ 3.0 Tesla magnetic resonance imaging มาใช้ในทางการแพทย์ แต่ประสบการณ์ของการใช้ 3.0 Tesla CMR ในการตรวจวินิจฉัยในหลอดเลือดและหัวใจยังจำกัดอยู่*

วัตถุประสงค์*: เพื่อรายงานถึงประสบการณ์ของการใช้เครื่อง 3.0 Tesla CMR สำหรับการตรวจวินิจฉัยโรคหัวใจและหลอดเลือดที่โรงพยาบาลรามาธิบดี*

วัสดุและวิธีการ*: ประเมินข้อมูลจากผู้ป่วยที่ได้ถูกส่งมาตรวจ CMR ระหว่างเดือนสิงหาคม พ.ศ. 2547 ถึง ตุลาคม พ.ศ. 2548*

ผลการศึกษา*: การศึกษานี้ประกอบด้วยผู้ป่วย 100 คน ซึ่งมีอายุเฉลี่ย 56 ปี (2 เดือน ถึง 85 ปี) และ 65 คนเป็นเพศชาย ข้อบ่งชี้ในการตรวจที่มากที่สุดคือการตรวจ เพื่อวินิจฉัยภาวะหลอดเลือดหัวใจตีบ (64 คน) ชนิดของการตรวจแบ่งได้เป็น การตรวจพยาธิสภาพ และหน้าที่ของการทำงานหัวใจ (39%) การตรวจสมรรถภาพของหัวใจขณะให้ยา (23%) การตรวจหลอดเลือดหัวใจ (13%) การตรวจดูถึงภาวะกล้ามเนื้อหัวใจที่มีชีวิตอยู่ (12%) ตรวจดูหลอดเลือดส่วนอื่นของร่างกาย (9%) และการตรวจวัดปริมาณของเลือดที่ไหลเวียนในหลอดเลือดใหญ่ (4%)*

สรุป*: การศึกษานี้แสดงให้เห็นว่าการตรวจด้วยเครื่อง 3.0 Tesla CMR สามารถให้ข้อมูลที่มีประโยชน์ในการวินิจฉัยโรคหัวใจและหลอดเลือดชนิดต่าง ๆ*