MRI hodnocení levé komory

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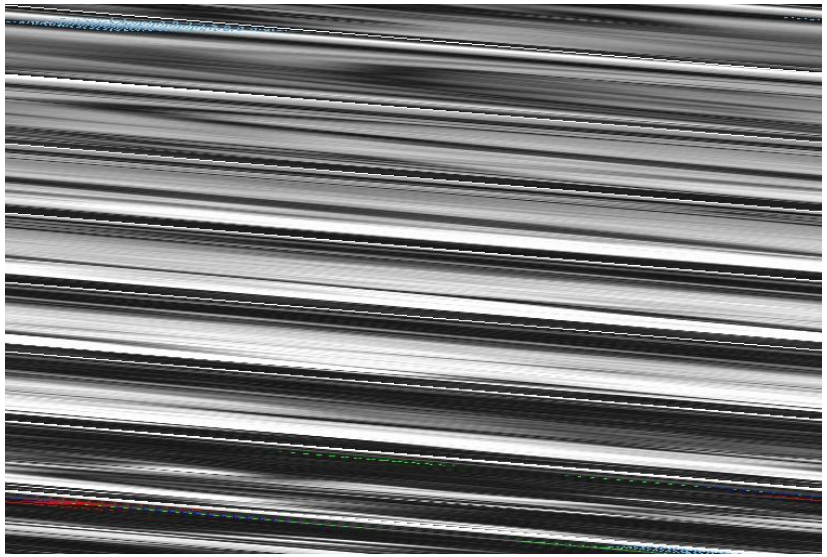
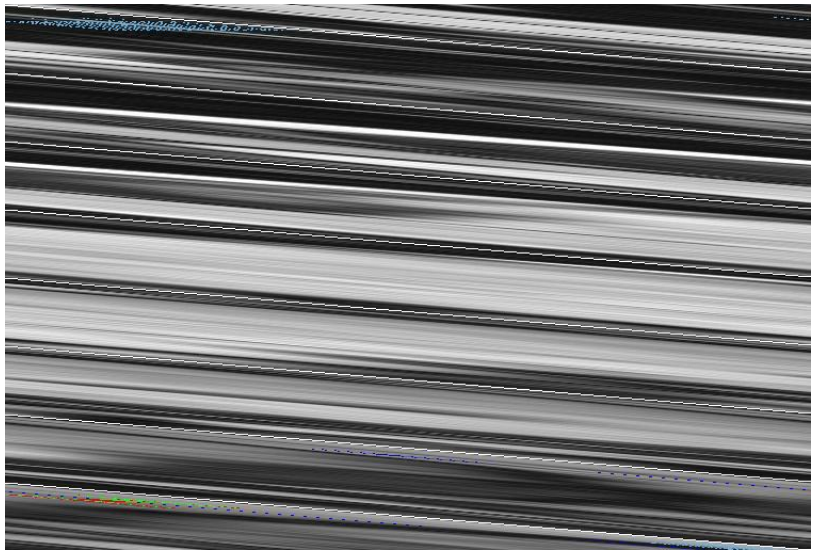
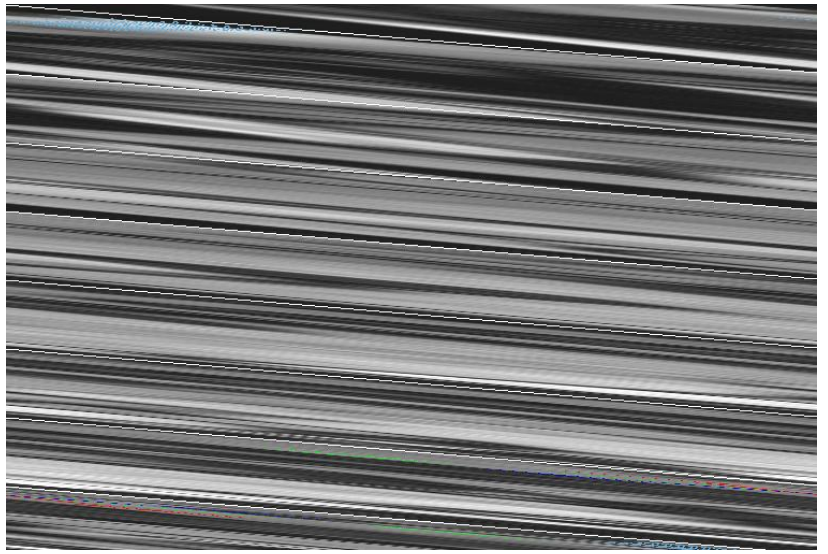
MRI hodnocení LK

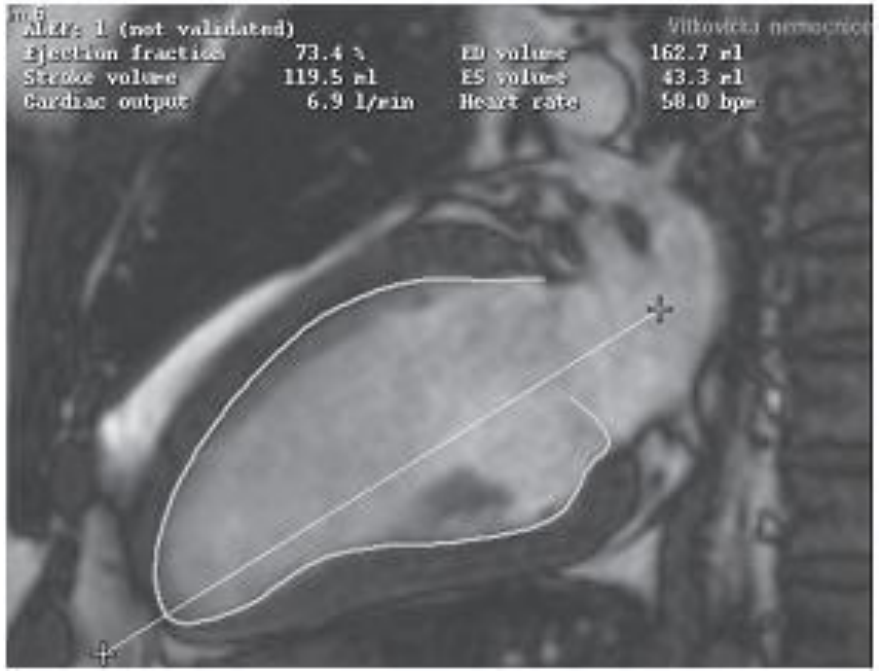
- velikost a tvar LK, hmotnost myokardu LK (LVM)
- systolická funkce
- diastolická funkce
- charakteristika stěn LK:

- diametr
- kinetika
- struktura (tkáňová charakteristika)

Objemy a systolická funkce

Rovnice plocha – délka



Objem LK = 0,85 x plocha^2 /délka

Simpson´s rule

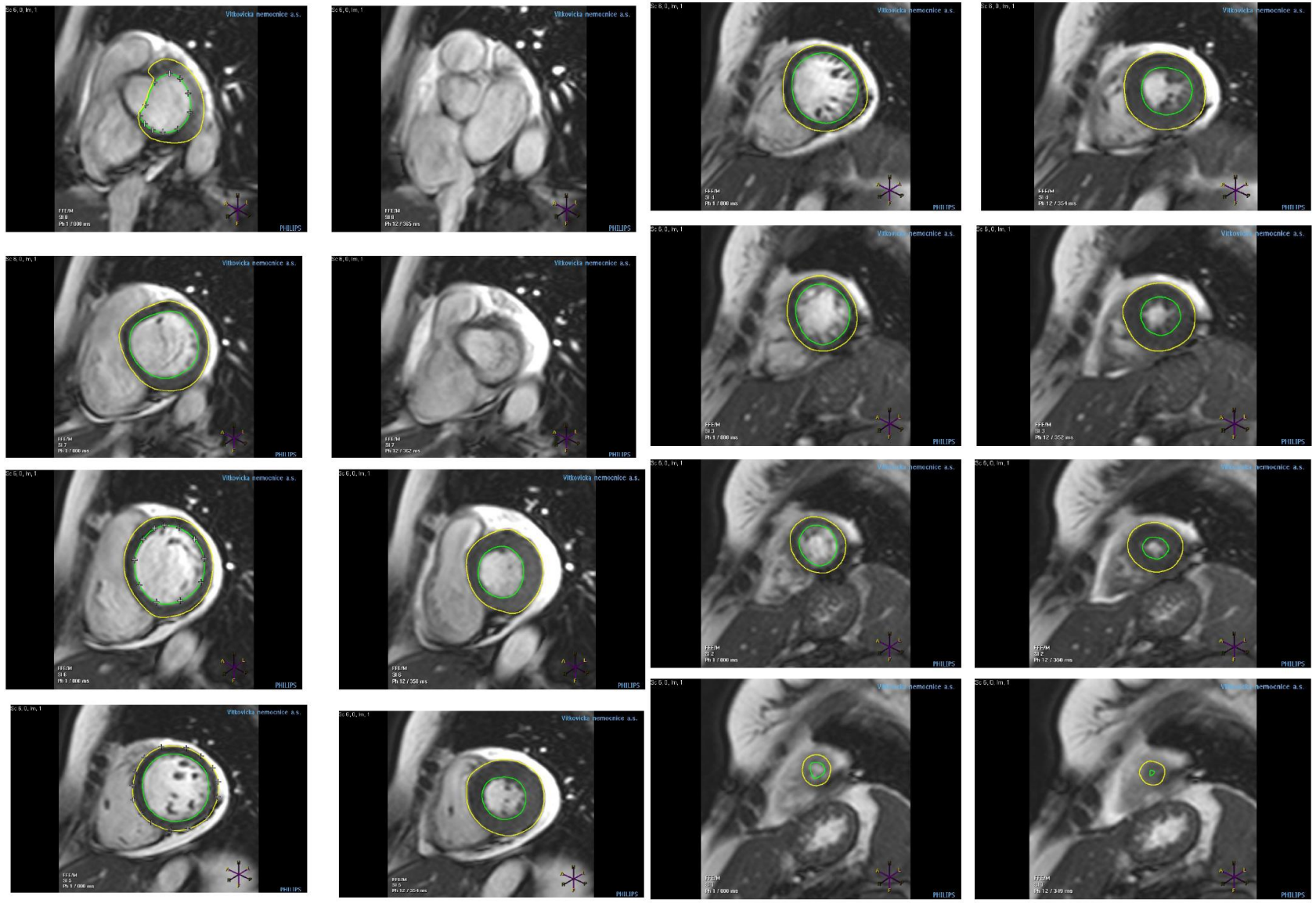
EDV/EDVI

ESV/ESVI

EF LK

SV

LVM



MRI – „zlatý standard“

CMR is recommended for the assessment of myocardial structure and function (including right heart) in subjects with poor acoustic window and patients with complex congenital heart diseases (taking account of cautions/contra-indications to CMR).	I	C

ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur J Heart Fail.* 2016;18(8):891–975.

- diskrepance mezi výsledky předchozích vyšetření/metod

- ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging: a report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology. *J Am Coll Cardiol.* 2006;48(7):1475–1497.

- před implantací ICD v rámci primární prevence

- Korean guidelines for appropriate utilization of cardiovascular magnetic resonance imaging: a joint report of the Korean Society of Cardiology and the Korean Society of Radiology. *Korean J Radiol.* 2014;15(6):659-688.

MRI normy

Table 3 Left ventricular parameters, by age and gender [mean ± SD (lower, upper limits*)]

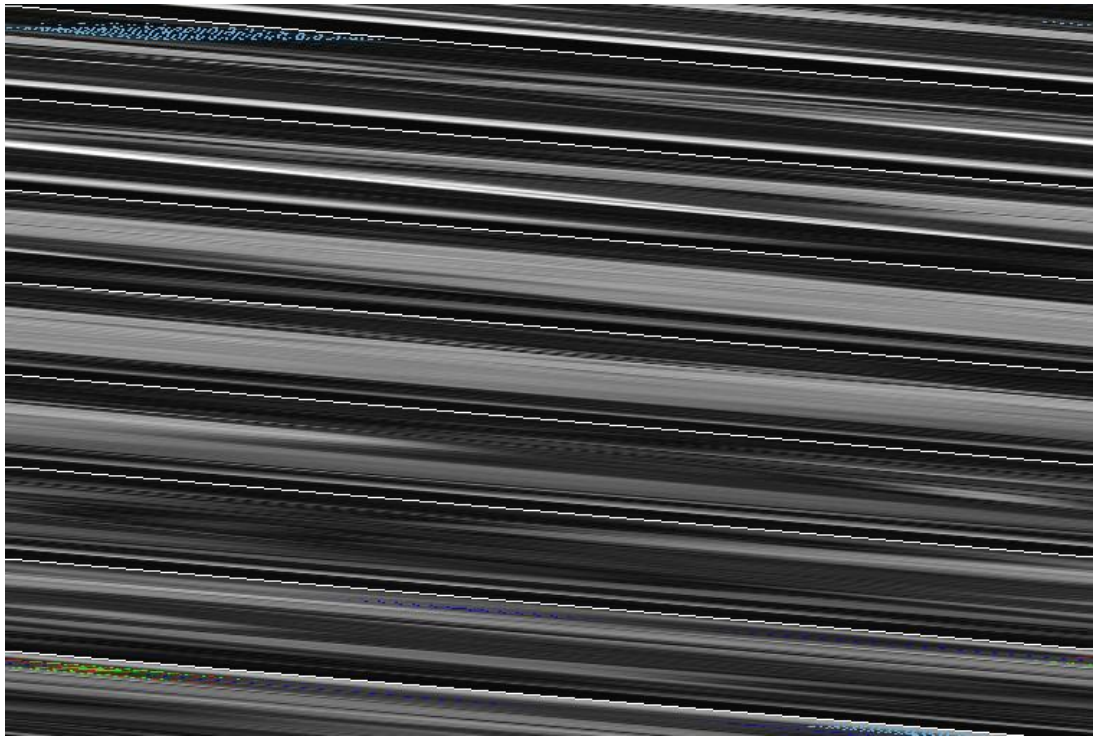
	Men		Women	
Parameter	**<60 years**	**≥60 years**	**<60 years**	**≥60 years**
EDV [ml]	161 ± 21 (119, 203)	148 ± 21 (106, 190)	132 ± 21 (90, 174)	120 ± 21 (78, 162)
EDV /BSA [ml/m^2]	82 ± 9 (64, 100)	76 ± 9 (58, 94)	78 ± 8.7 (61, 95)	69 ± 8.7 (52, 86)
ESV [ml]	55 ± 11 (33, 77)	48 ± 11 (26, 70)	44 ± 9.5 (25, 63)	38 ± 9.5 (19, 57)
ESV/BSA [ml/m^2]	28 ± 5.5 (17, 39)	25 ± 5.5 (14, 36)	26 ± 4.7 (17, 35)	22 ± 4.7 (13, 31)
SV [ml]	106 ± 14 (78, 134)	100 ± 14 (72, 128)	88 ± 14 (60, 116)	82 ± 14 (54, 110)
SV/BSA [ml/m^2]	55 ± 6.1 (43, 67)	52 ± 6.1 (40, 64)	52 ± 6.2 (40, 64)	47.5 ± 6.2 (35, 60)
EF [%]	66 ± 4.5 (57, 75)	68 ± 4.5 (59, 77)	67 ± 4.6 (58, 76)	69 ± 4.6 (60, 78)
Mass [g]	147 ± 20 (107, 187)	145 ± 20 (105, 185)	106 ± 18 (70, 142)	110 ± 18 (74, 146)
Mass/BSA [g/m^2]	74 ± 8.5 (57, 91)	73 ± 8.5 (56, 90)	62 ± 7.5 (47, 77)	63 ± 7.5 (48, 78)

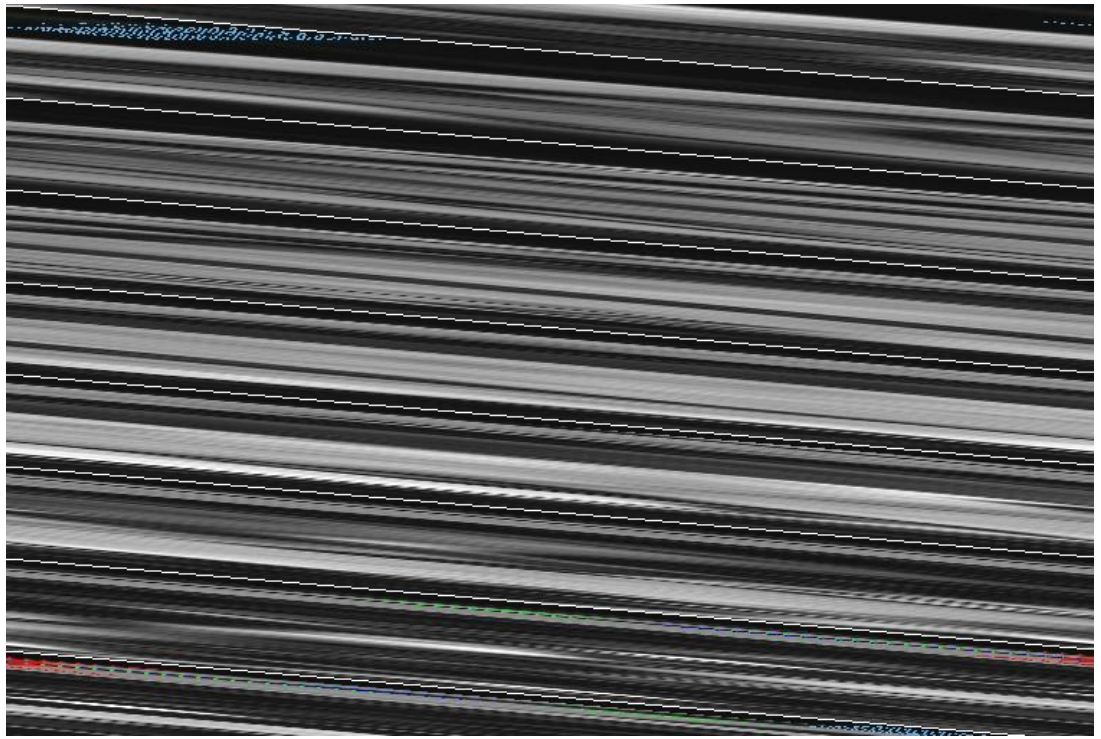
LV papillary muscle mass included as part of LV mass. From reference [5].

*= calculated as mean ±2*SD; EDV = end-diastolic volume; ESV = end-systolic volume; SV = stroke volume; EF = ejection fraction; BSA = body surface area; SD = standard deviation.

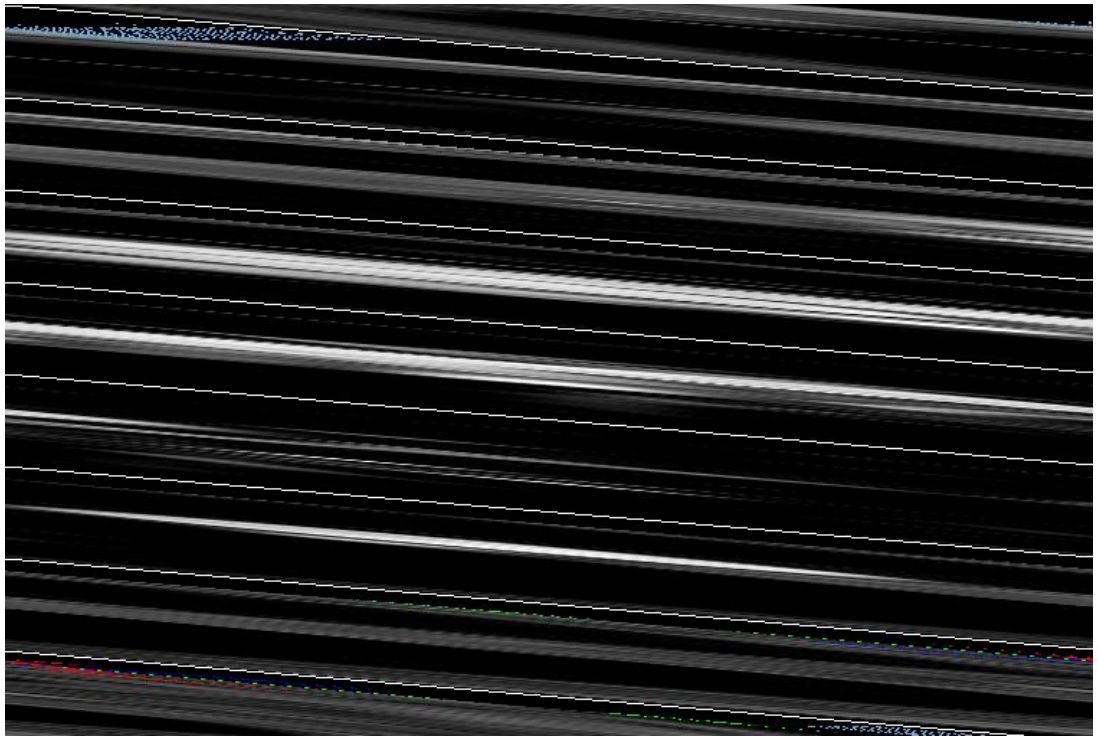
Kawel-Boehm N et al. Normal values for cardiovascular magnetic resonance in adults and children. *Journal of Cardiovascular Magnetic Resonance.* 2015;17:29.

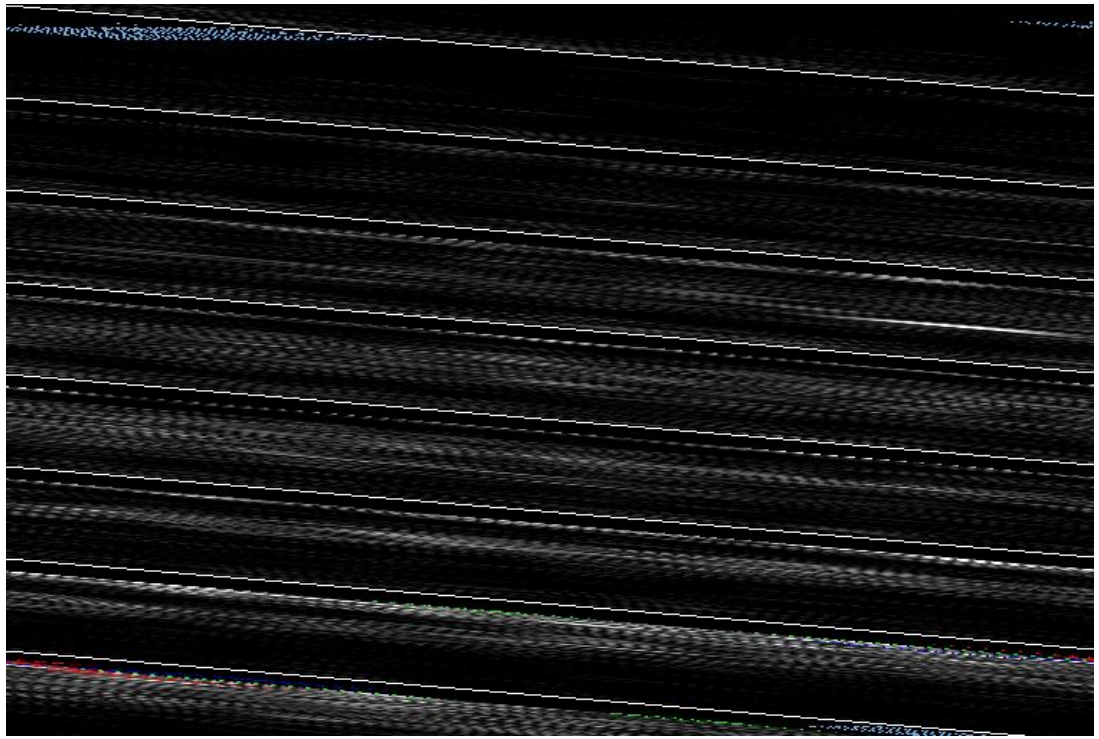
Tvar LK



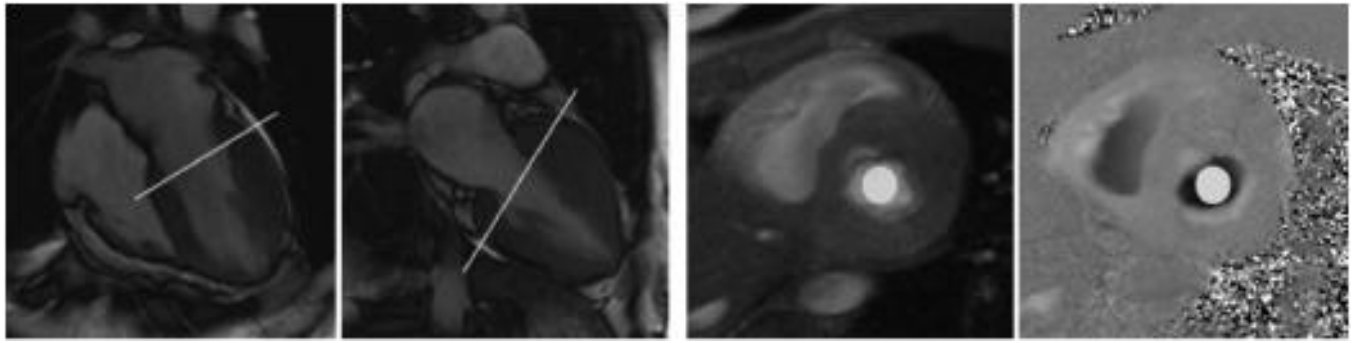


Hodnocení diastolické dysfunkce LK





Metoda fázového kontrastu



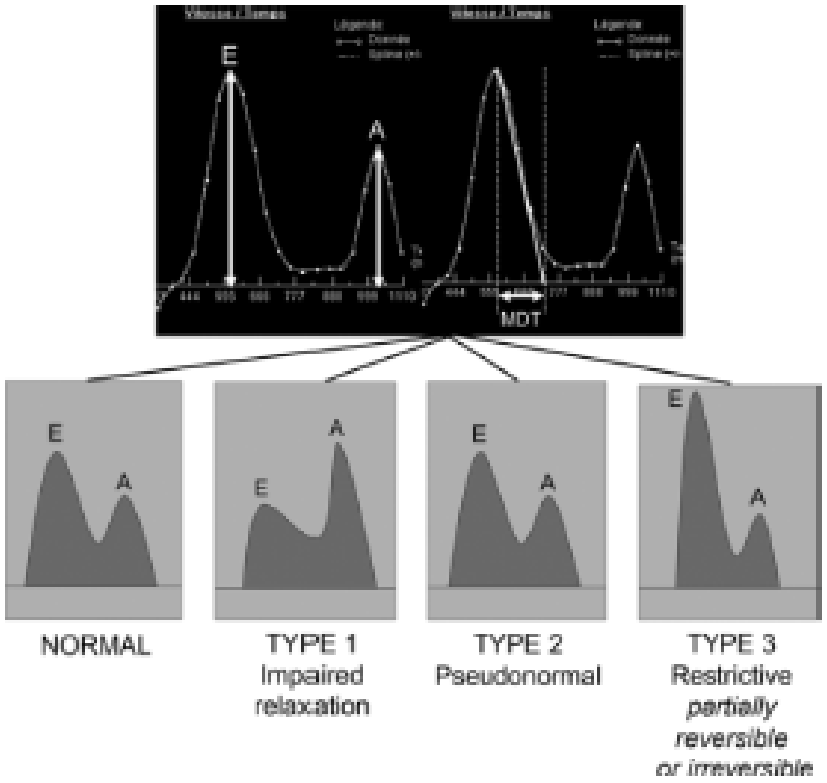
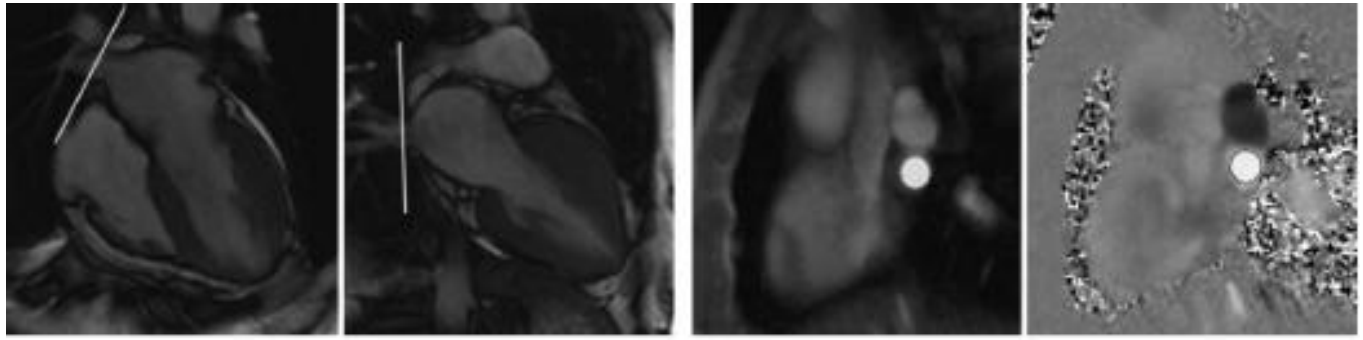


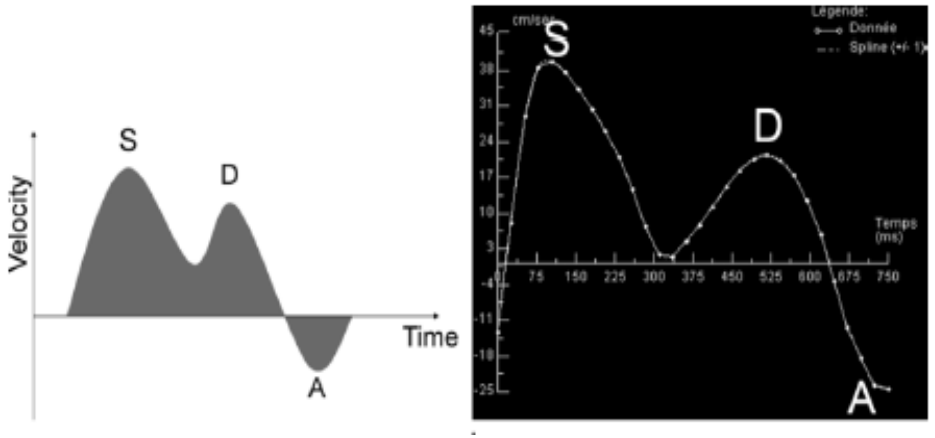
Table 2
Types of TMF Patterns

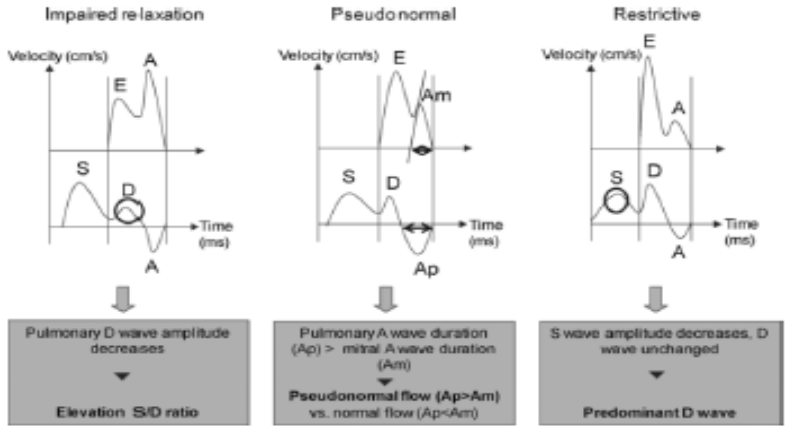
Characteristics	Normal	Type 1	Type 2*	Type 3	
Pattern	Normal	Impaired relaxation	Pseudonormal	Restrictive (partially reversible)	Restrictive (fixed)
E/A ratio	1–2	<1	1–2	>2	>2
MDT† (msec)	150–220	Increased	Normal	Decreased	Decreased
Mechanism	...	Abnormal relaxation	Combination of abnormal relaxation and stiffness with opposite effects; transition between types 1 and 3	Abnormal LV stiffness; partially reversible with medical treatment	Abnormal LV stiffness; irreversible despite medical treatment
LV filling pressures	Normal	Normal or slightly increased	Mildly increased	Moderately increased	Greatly increased
Main causes	...	LV hypertrophy, hypertension, ischemic cardiomyopathies, diabetes mellitus, aging	Identical to those of types 1 and 3	Severe LV dysfunction, restrictive cardiomyopathy (eg, cardiac amyloidosis), chronic constrictive pericarditis	Severe LV dysfunction, restrictive cardiomyopathy (eg, cardiac amyloidosis), chronic constrictive pericarditis

*To differentiate between the type 2 and normal patterns, other criteria are important (LA size, pulmonary venous flow [PVF], tissue phase-contrast [TPC]).
†MDT = mitral deceleration time.

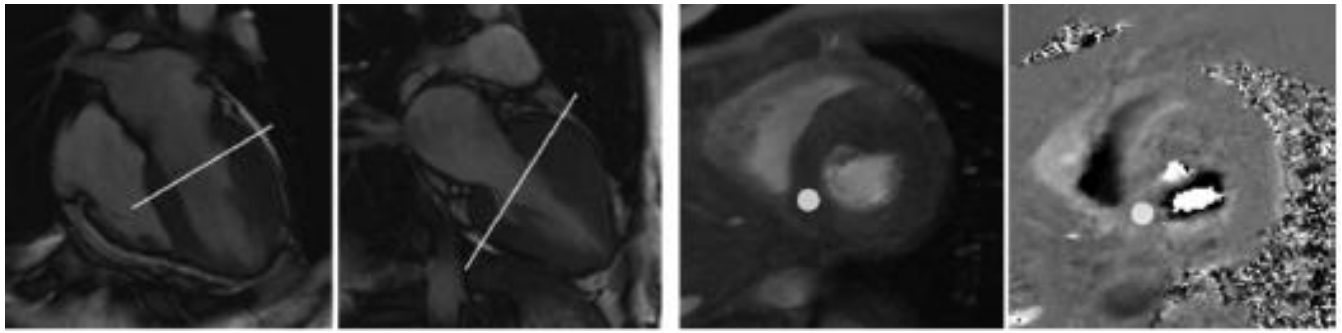
Caudron J et al. Evaluation of Left Ventricular Diastolic Function with Cardiac MR Imaging. *RadioGraphics*. 2011; 31:239–261

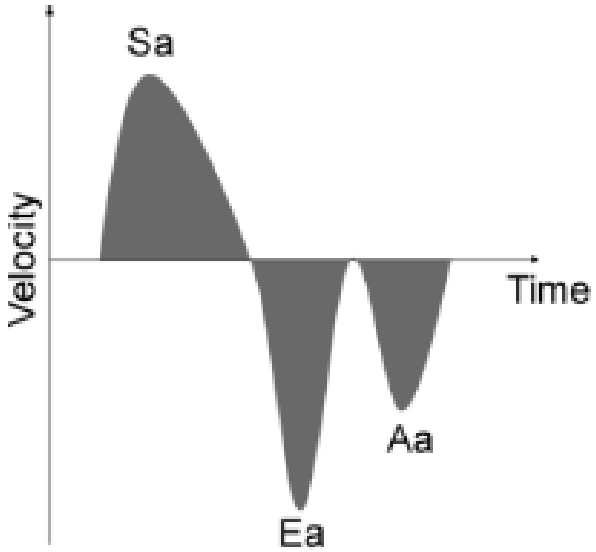


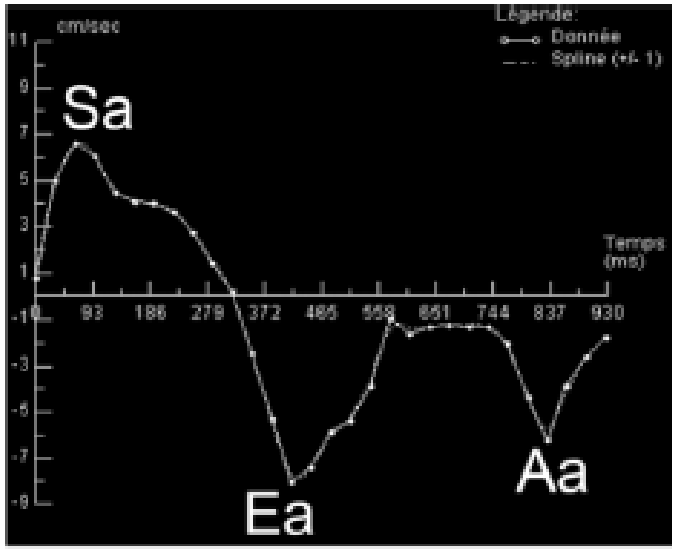


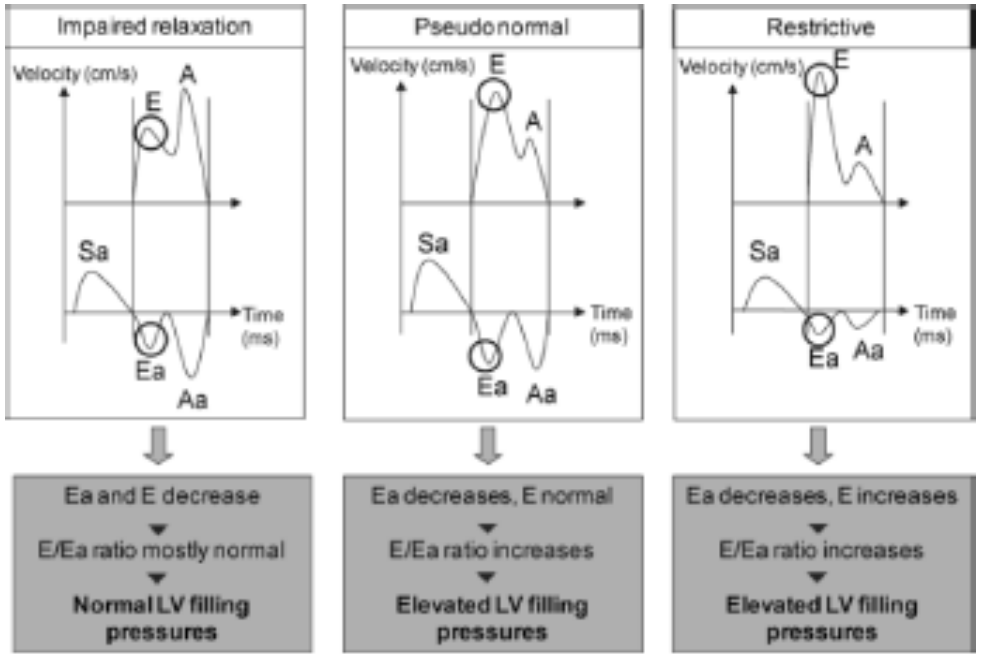


Caudron J et al. Evaluation of Left Ventricular Diastolic Function with Cardiac MR Imaging. *RadioGraphics*. 2011; 31:239–261

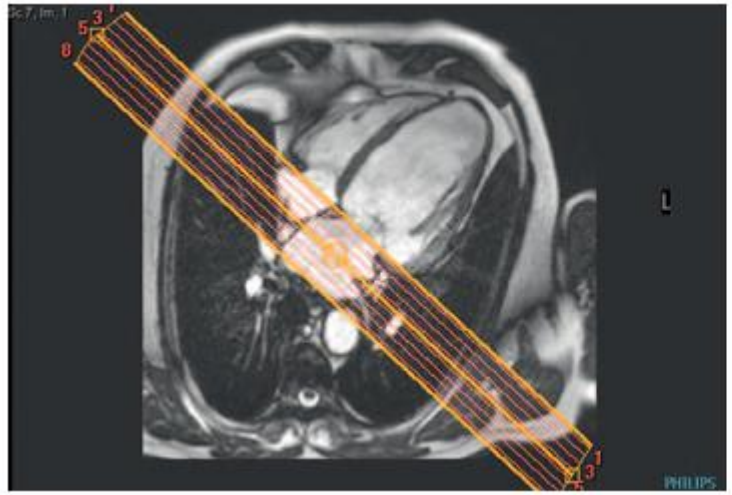


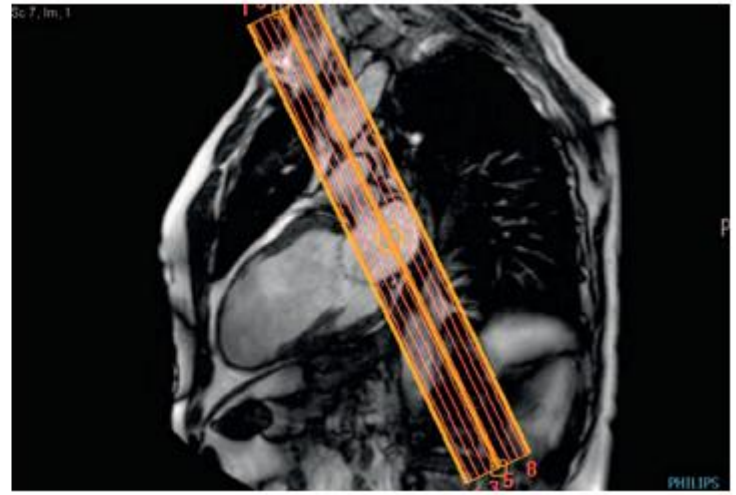


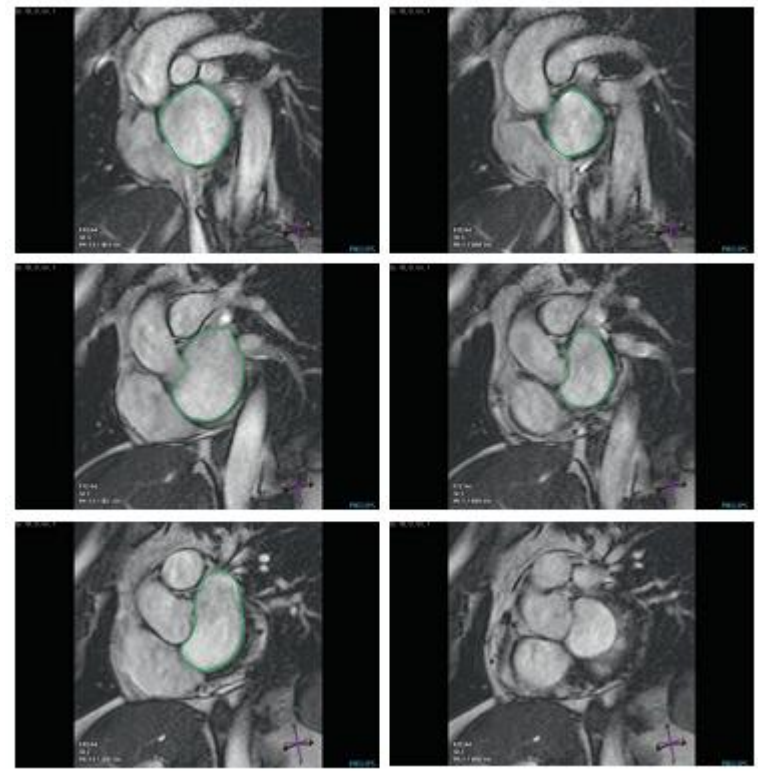




Caudron J et al. Evaluation of Left Ventricular Diastolic Function with Cardiac MR Imaging. *RadioGraphics*. 2011; 31:239–261







Panovsky R et al. Left atrium assessment: the evolving role of MRI. J Cardiovasc Med. 2014;15:000-000.

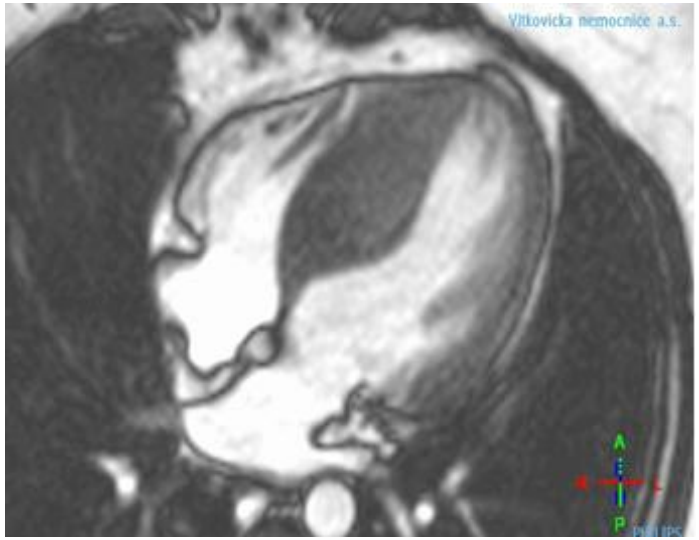
MRI hodnocení diastolické funkce

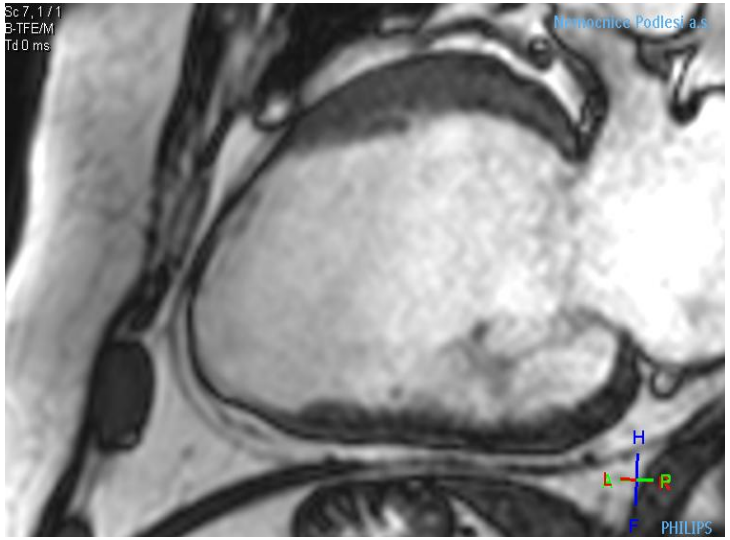
Tabulka 3.1 – Definice srdečního selhání se zachovanou ejekční frakcí (HFpEF), s ejekční frakcí ve středním pásmu (HFmrEF) a sníženou ejekční frakcí (HFrEF)

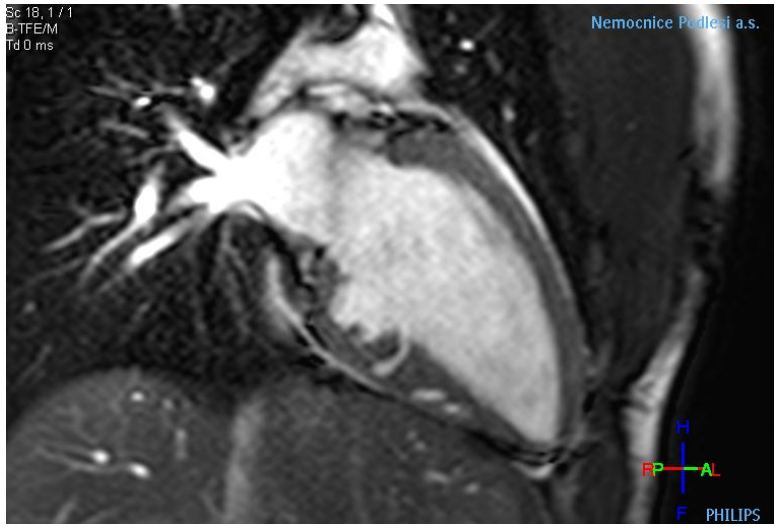
Typ srdečního selhání		HFrEF	HFmrEF	HFpEF
KRITÉRIA	1	Symptomy ± známky[a]	Symptomy ± známky[a]	Symptomy ± známky[a]
	2	EFLK < 40 %	EFLK 40–49 %	EFLK ≥ 50 %
	3	–	Zvýšené hodnoty natriuretických peptidů[b] Alespoň jedno další kritérium: • významné strukturální onemocnění srdce (HLK a/nebo LAE) • diastolická dysfunkce (detaily viz oddíl 4.3)	Zvýšené hodnoty natriuretických peptidů[b] Alespoň jedno další kritérium: • významné strukturální onemocnění srdce (HLK a/nebo LAE) • diastolická dysfunkce (detaily viz oddíl 4.3)

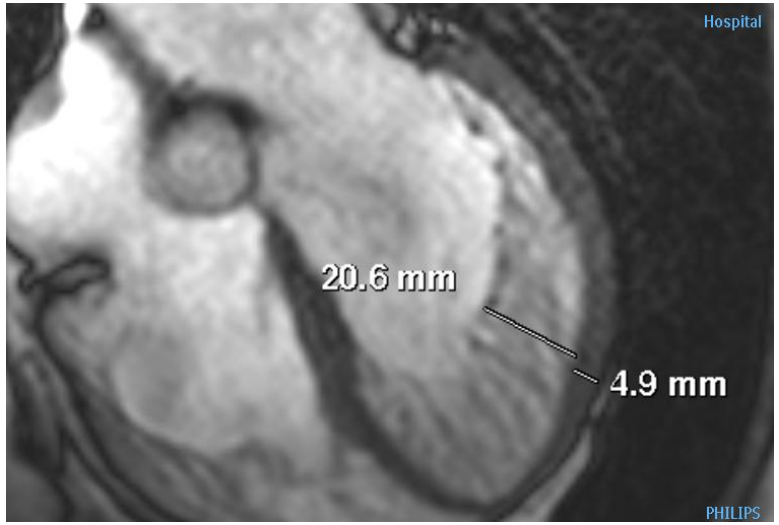
Špinar J. et al. Summary of the 2016 ESC Guidelines on the diagnosis and treatment of acute and chronic heart failure. Prepared by the Czech Society of Cardiology. Cor et Vasa. 2016;58:e530–e568.

Diametr stěn



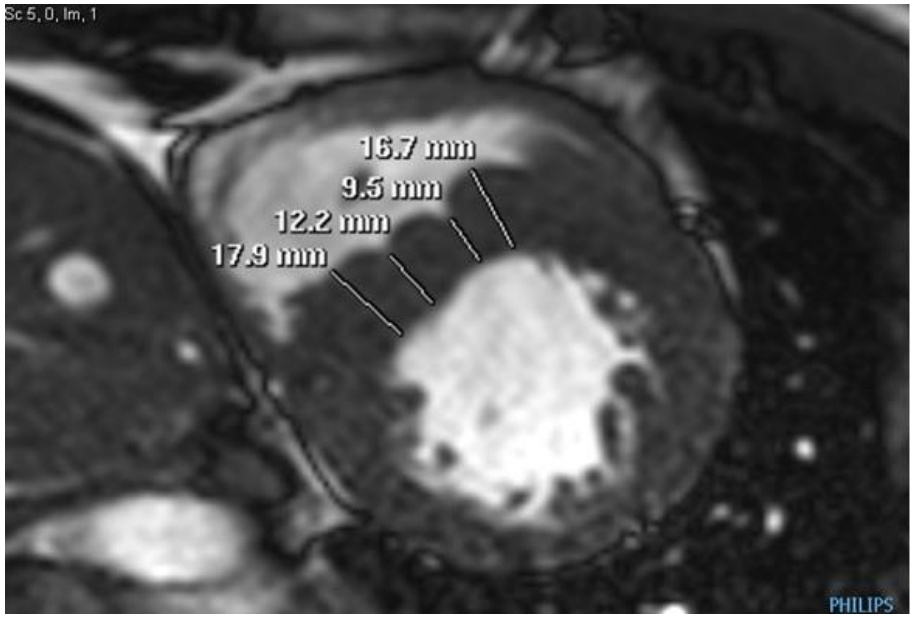


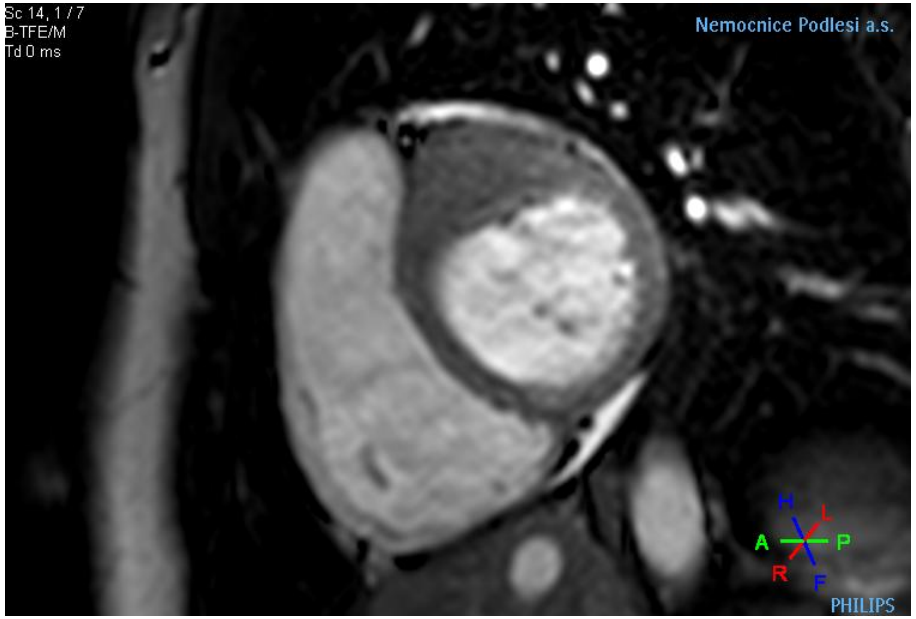




Hypertrofie LK

- maximum hypertrofie a jeho lokalizace
- symetrická/asymetrická
- fokální/difuzní
- kontinuální/nekontinutální





MRI normy

Table 28 Normal left ventricular myocardial thickness in mm measured on short axis images for men and women

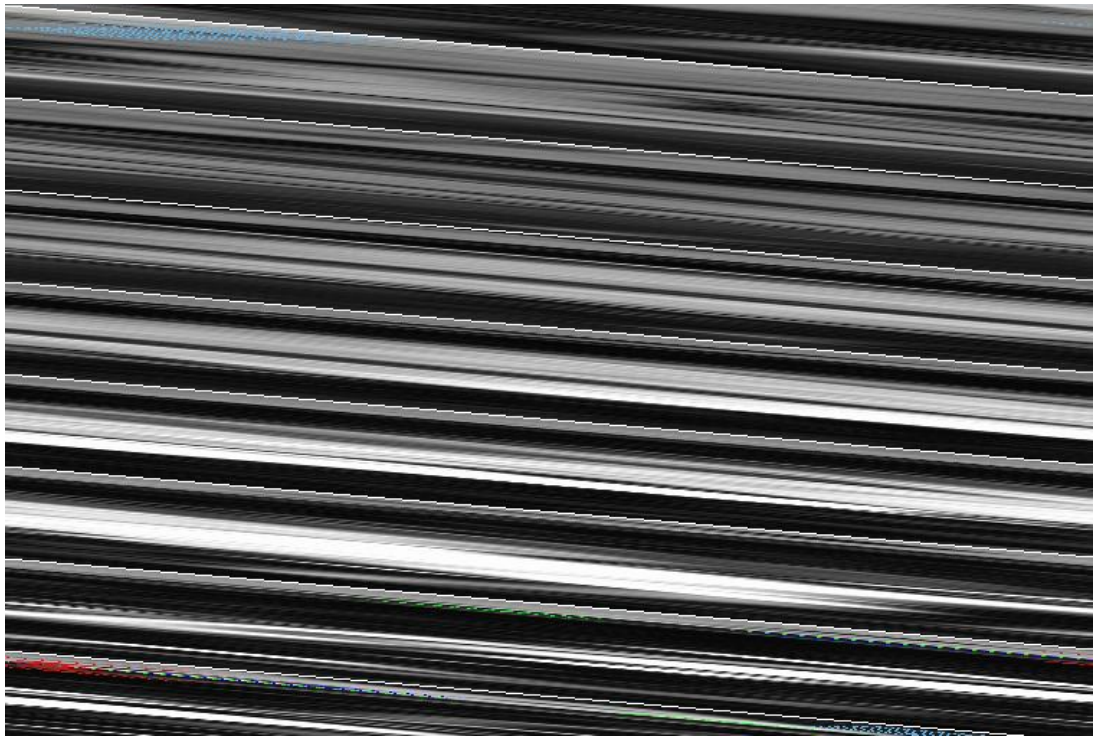
		Men			Women		
Level	Segment	$mean_p$	SD_p	Lower/upper limits*	$mean_p$	SD_p	Lower/upper limits*
basal	1	8.2	1.1	6.0-10.4	6.7	1.0	4.7-8.7
	2	9.6	1.1	7.4-11.8	7.9	1.0	5.9-9.9
	3	9.2	1.1	7.0-11.4	7.5	1.0	5.5-9.5
	4	8.1	1.1	5.9-10.3	6.6	1.0	4.6-8.6
	5	7.3	1.1	5.1-9.5	6.0	1.0	4.0-8.0
	6	7.4	1.1	5.2-9.6	6.1	0.9	4.3-7.9
mid-cavity	7	6.7	1.1	4.5-8.9	5.7	1.0	3.7-7.7
	8	7.7	1.1	5.5-9.9	6.4	1.0	4.4-8.4
	9	8.2	1.1	6.0-10.4	6.9	1.0	4.9-8.9
	10	7.0	1.1	4.8-9.2	5.9	1.0	3.9-7.9
	11	6.2	1.1	4.0-8.4	5.2	0.9	3.4-7.0
	12	6.4	1.1	4.2-8.6	5.4	1.0	3.4-7.4
apical	13	6.7	1.1	4.5-8.9	6.4	1.0	4.4-8.4
	14	7.3	1.1	5.1-9.5	6.3	1.0	4.3-8.3
	15	6.2	1.1	4.0-8.4	5.4	1.0	3.4-7.4
	16	6.3	1.1	4.1-8.5	5.9	1.0	3.9-7.9

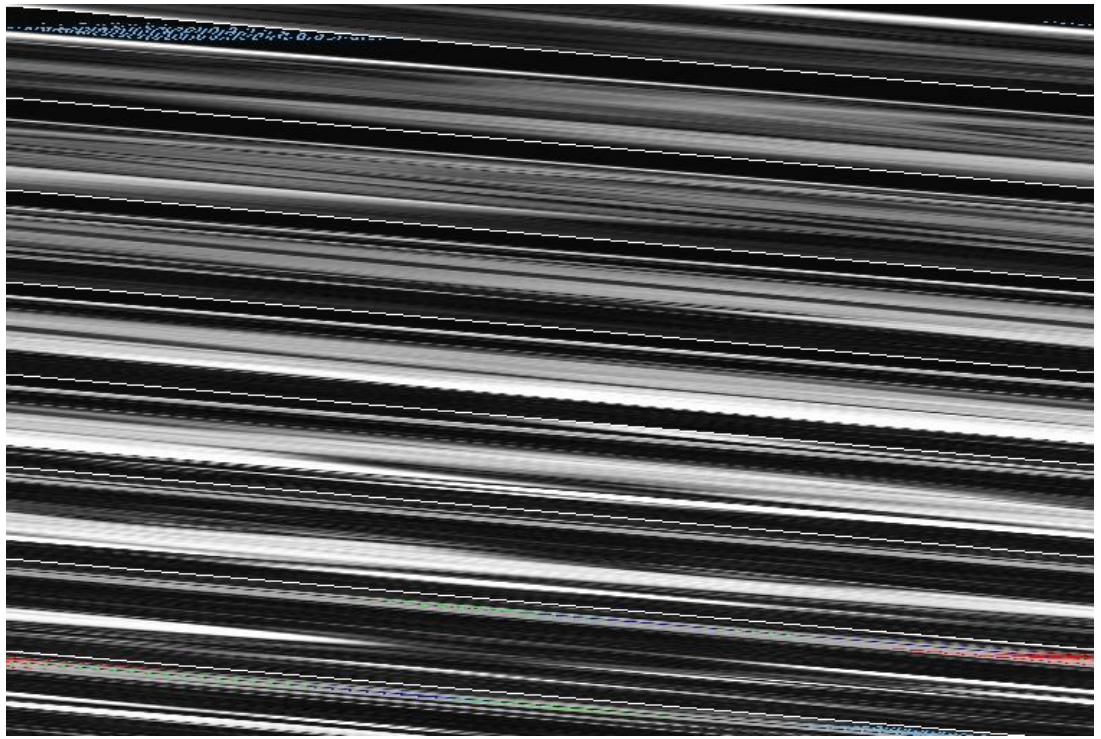
Pooled weighted mean values from references [29,30].

$mean_p$ = pooled weighted mean; SD_p = pooled standard deviation; * = calculated as $mean_p \pm 2*SD_p$; Segments: 1 = basal anterior, 2 = basal anteroseptal, 3 = basal inferoseptal, 4 = basal inferior, 5 = basal inferolateral, 6 = basal anterolateral, 7 = mid anterior, 8 = mid anteroseptal, 9 = mid inferoseptal, 10 = mid inferior, 11 = mid inferolateral, 12 = mid anterolateral, 13 = apical anterior, 14 = apical septal, 15 = apical inferior, 16 = apical lateral.

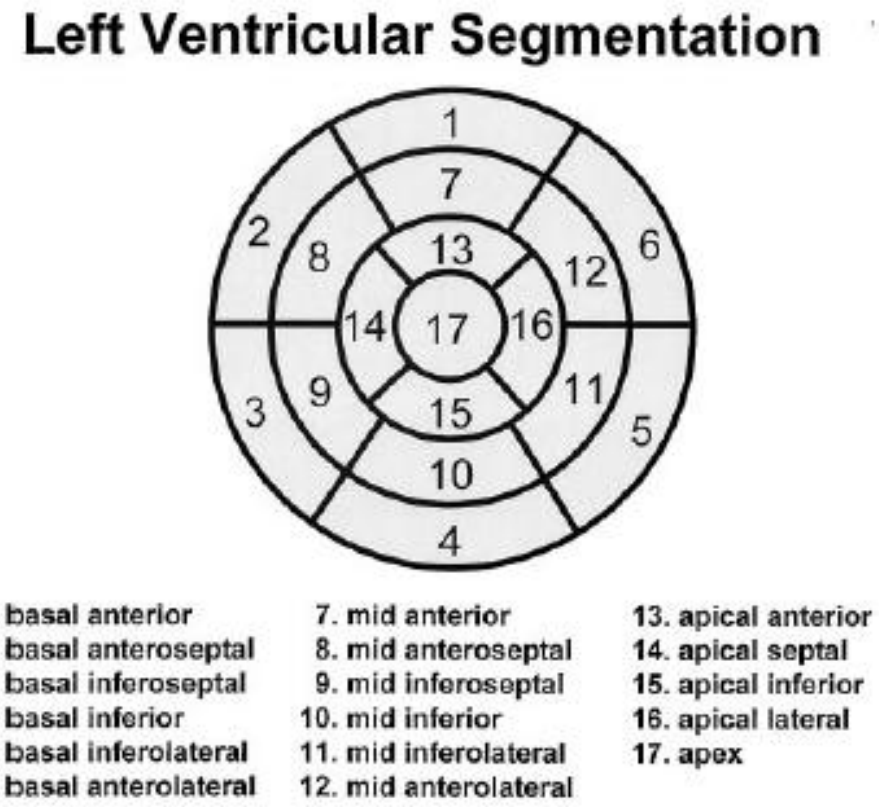
Kawel-Boehm N et al. Normal values for cardiovascular magnetic resonance in adults and children. *Journal of Cardiovascular Magnetic Resonance.* 2015;17:29.

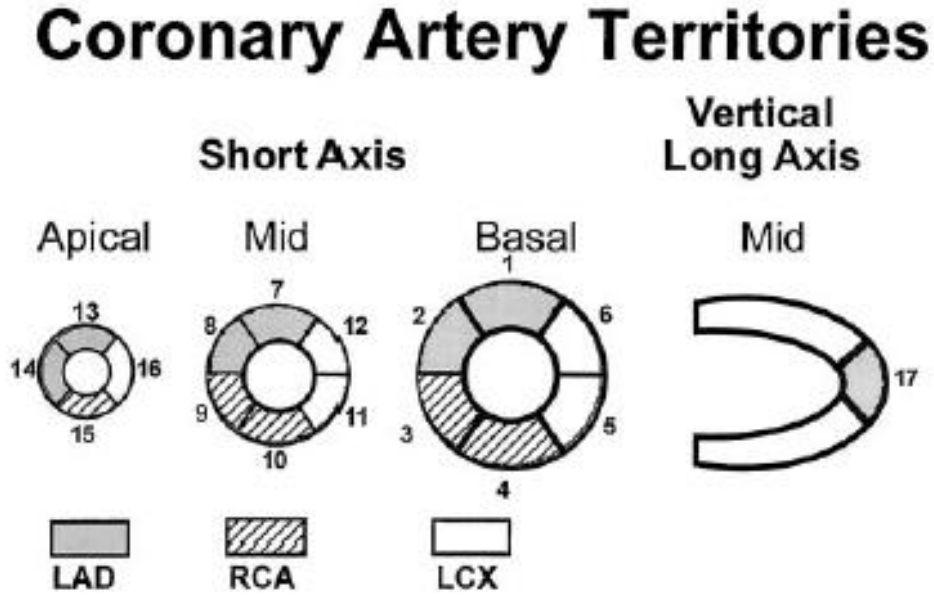
Kinetika stěn LK





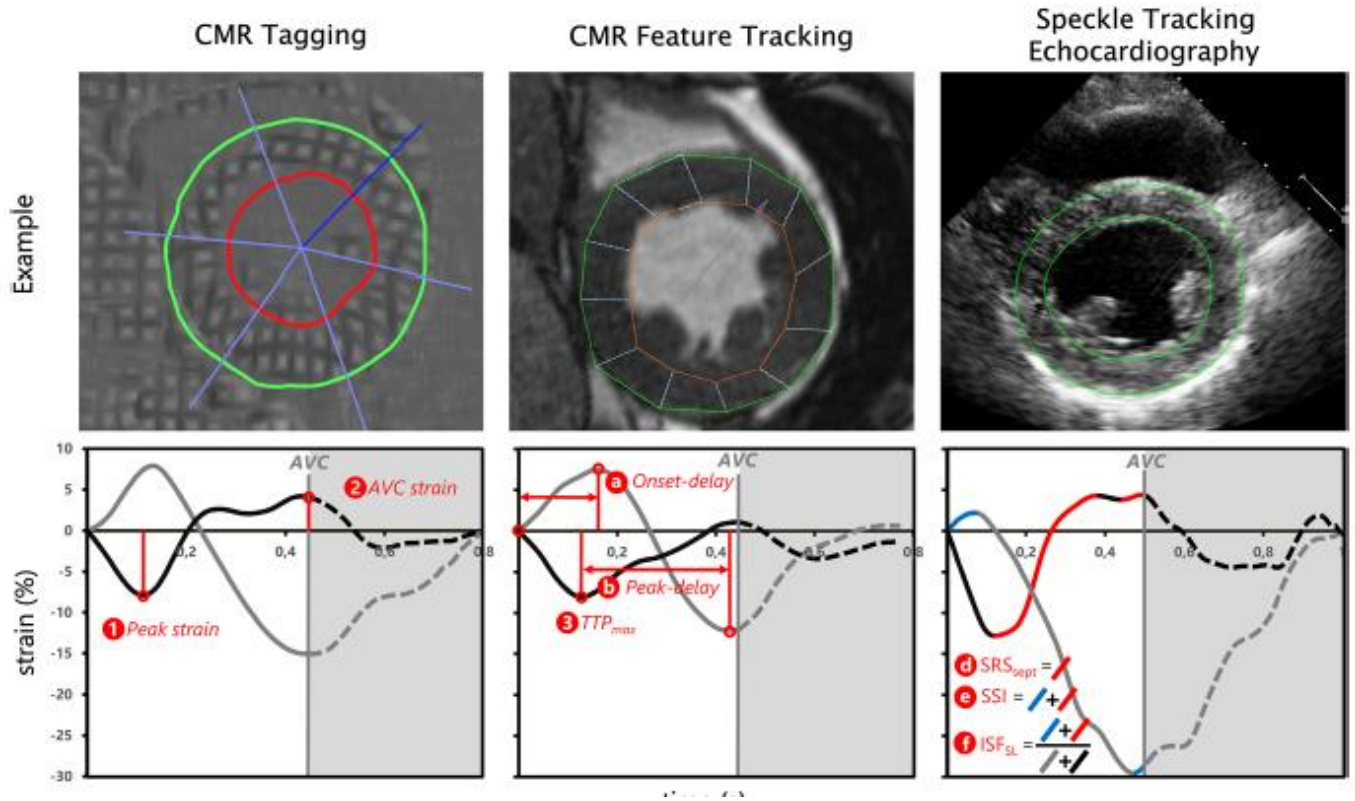
Hodnocení





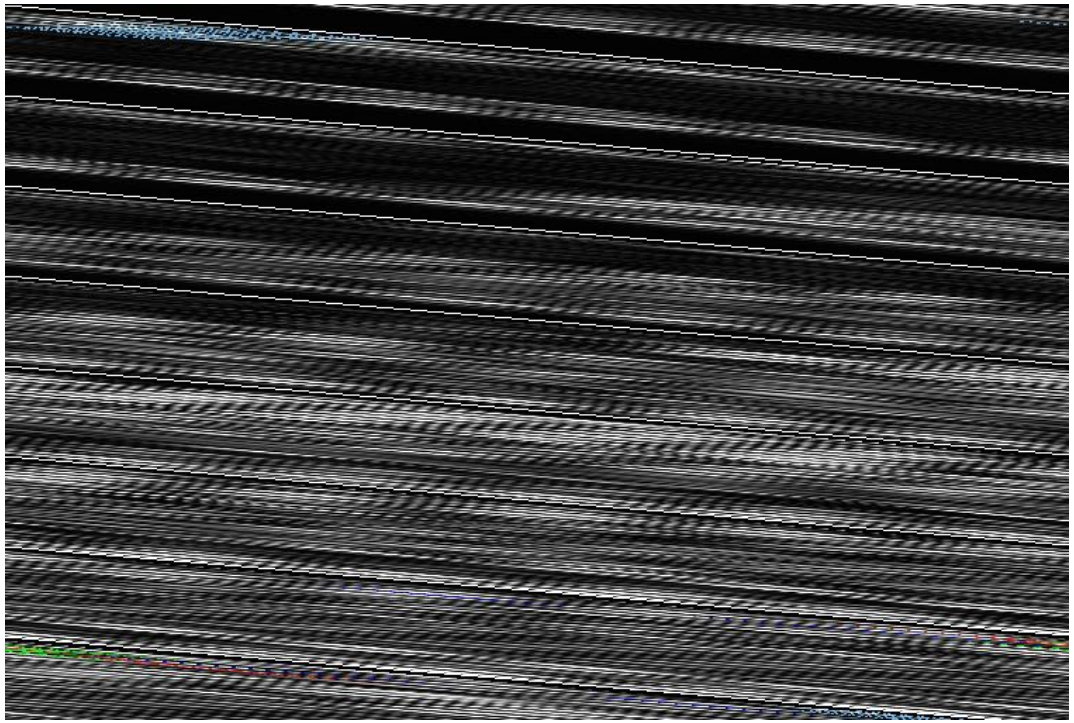
Cerqueira, MD et al. Standardized Myocardial Segmentation and Nomenclature for Tomographic Imaging of the Heart. *Circulation* 2002;105:539-542.

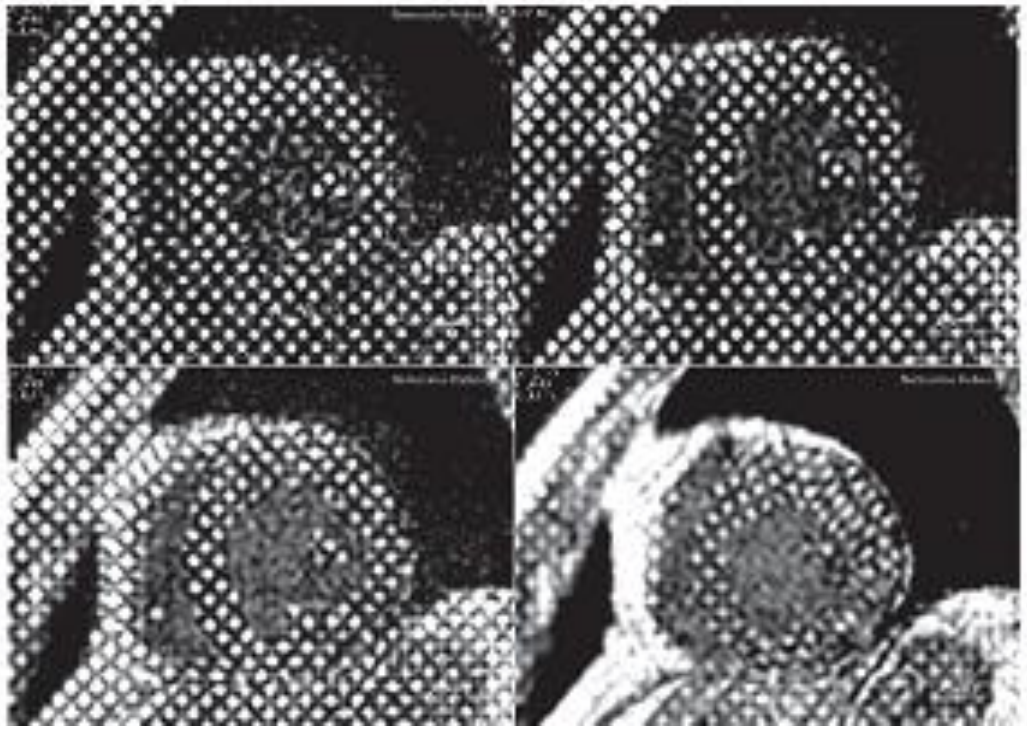
Deformace myokardu



van Everdingen WM et al. Comparison of strain imaging techniques in CRT candidates. International Journal Of Cardiovascular Imaging. 2018;34(3):443-456.

Tagging

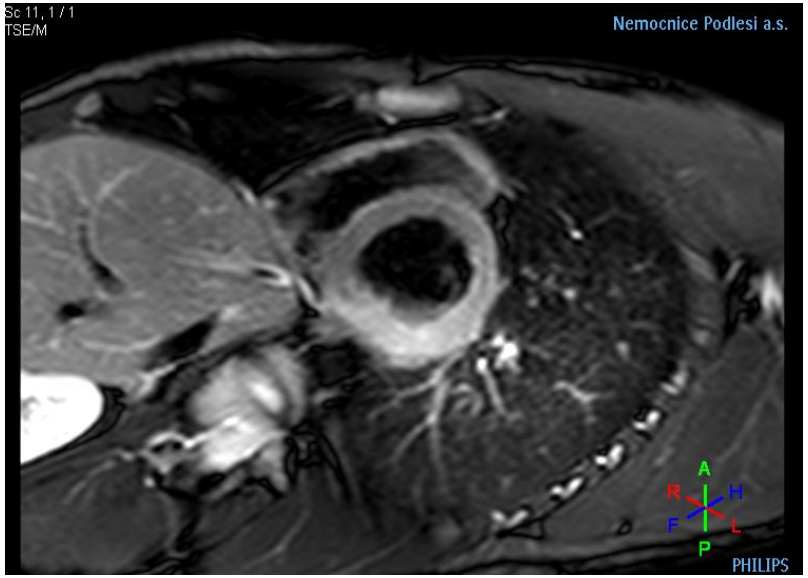




Tkáňová charakteristika myokardu LK

Standardní („neparametrické“) sekvence

T1W



T2W

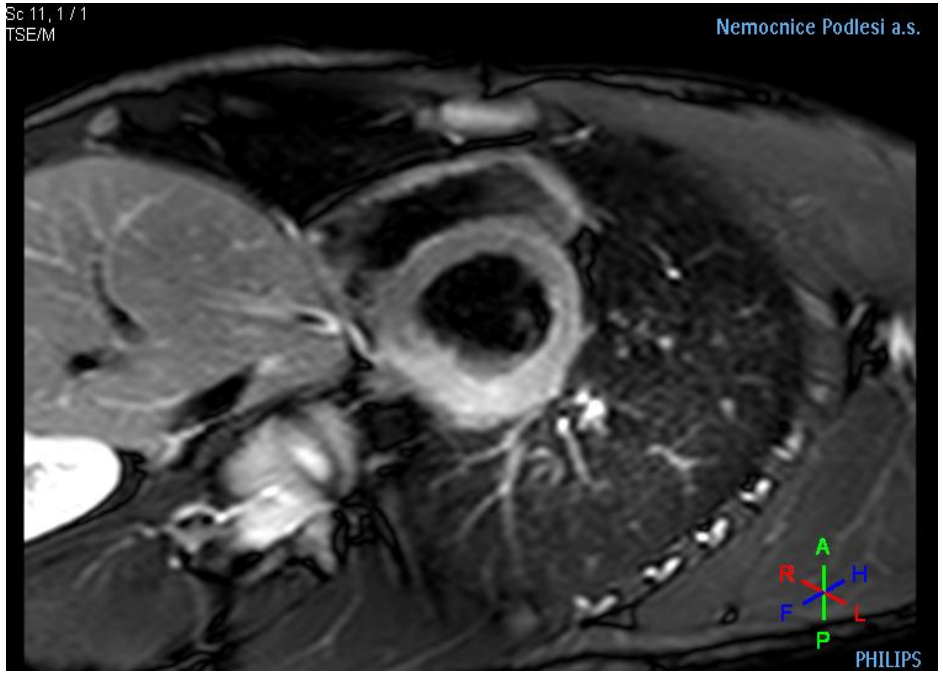
LGE

T1W obrazy – tuk v myokardu LK

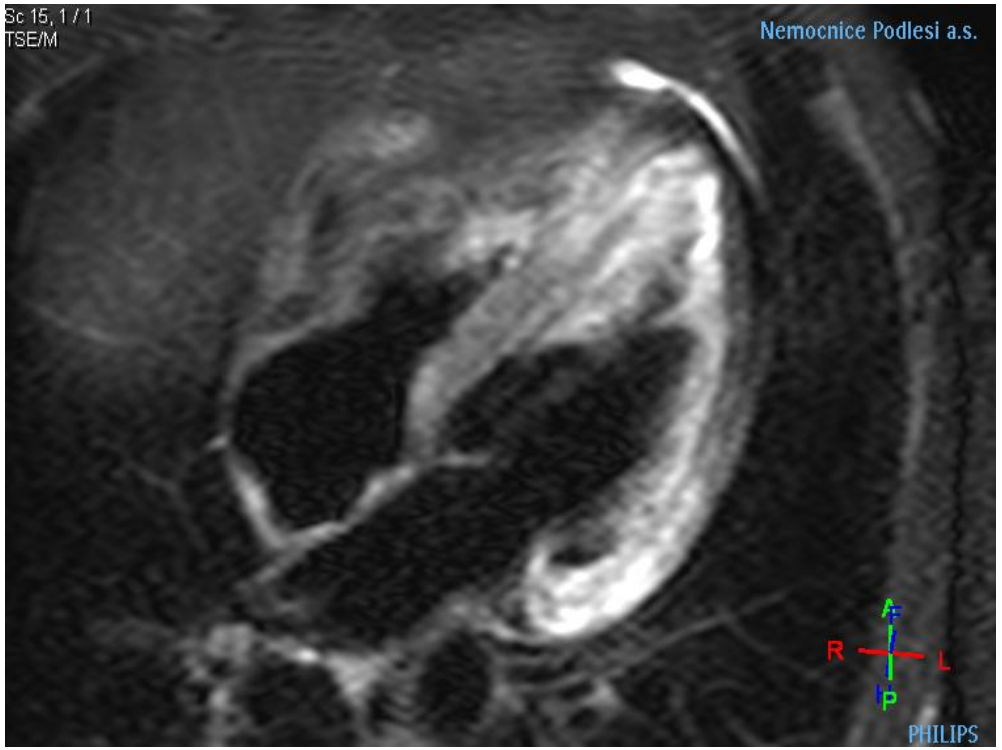
- fyziologicky
- arytmogenní kardiomyopatie
- tuková metaplázie IM (starší 6 měsíců)
- lipom, liposarkom
- tuberózní skleróza
- muskuloskeletární dystrofie
- DCM, HCM (raritně)

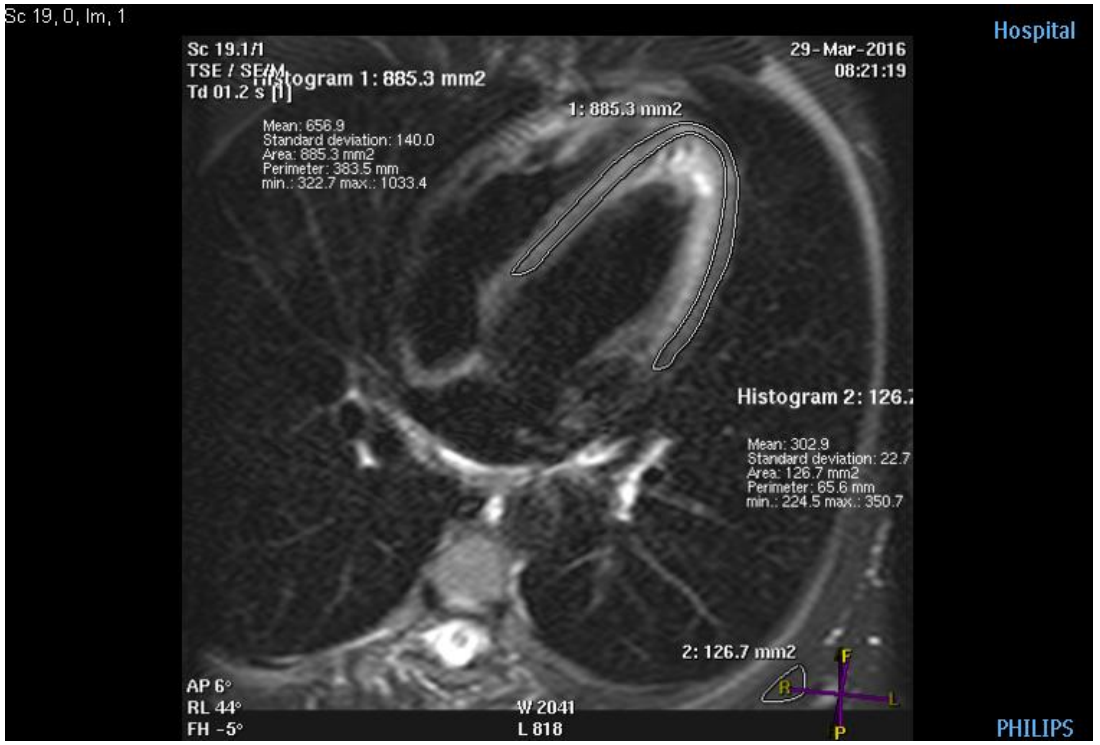
Edém myokardu LK

- AIM
- akutní myokarditis (včetně sarkoidózy)
- stresová KMP
- kontuze myokardu
- RF ablace



T2W obrazy – lokální a globální edém

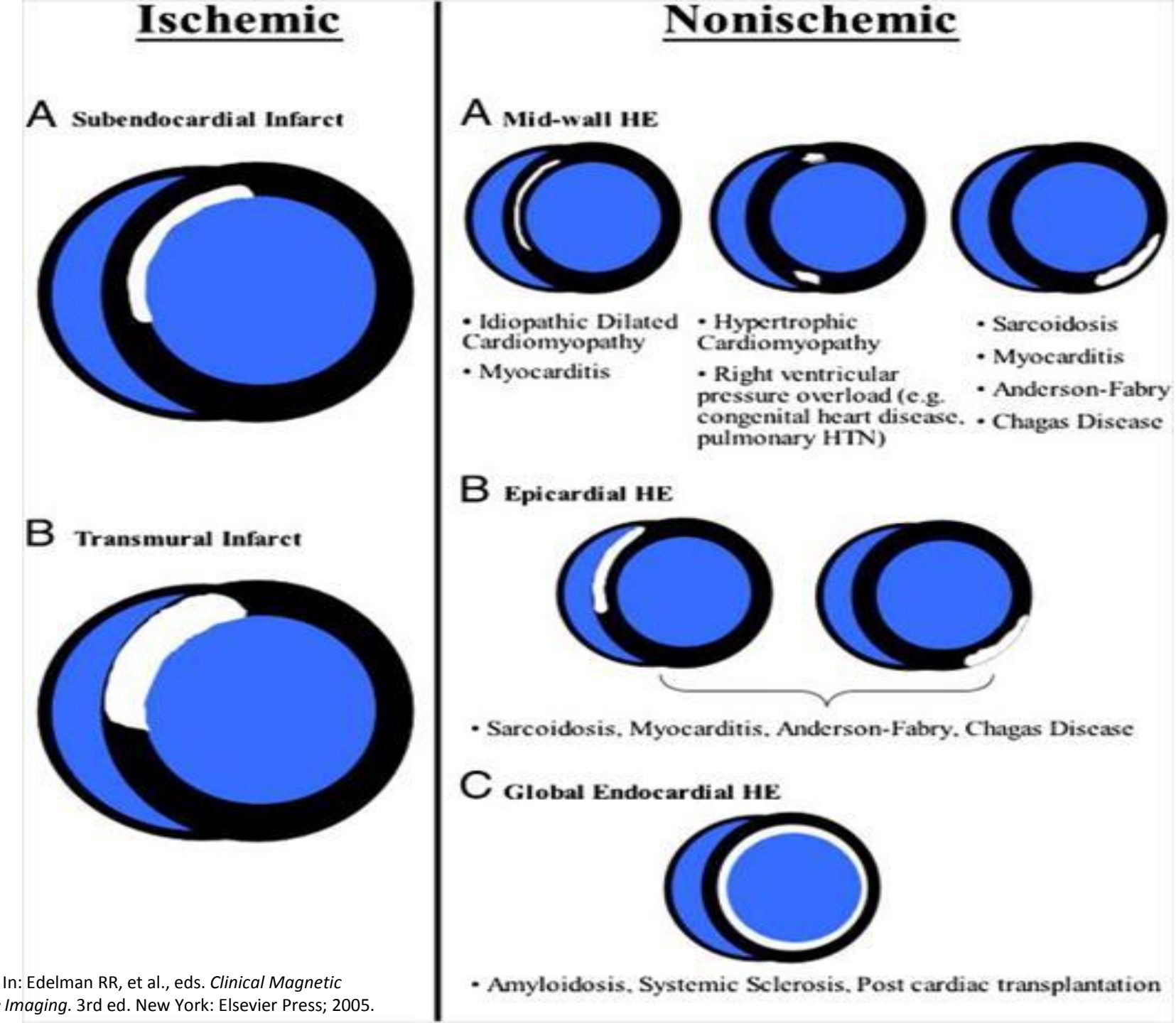




Edema ratio (SI myokardu/SI kosterního svalu) ≥ 2,0

Pozdní sycení (LGE)

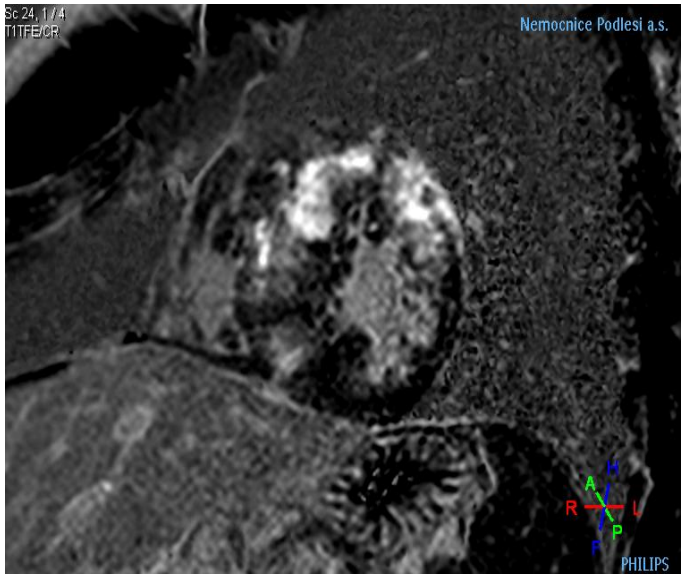
- MR kontrast (chelát gadolinia) má rozdílnou kinetiku ve viabilním myokardu a v jizvě
- zpomalený wash-in a wash-out
- pozdní scany s „vynulováním“ signálu zdravého myokardu
- nespecifický jev (fibróza, nekróza, amyloid)

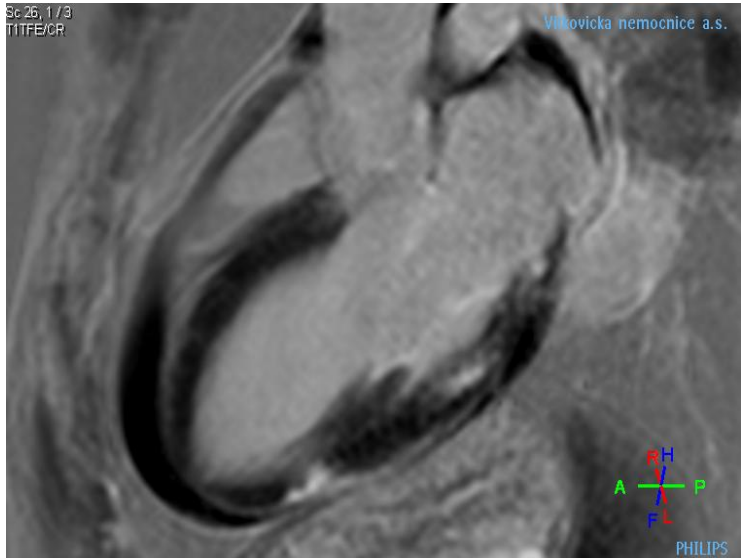


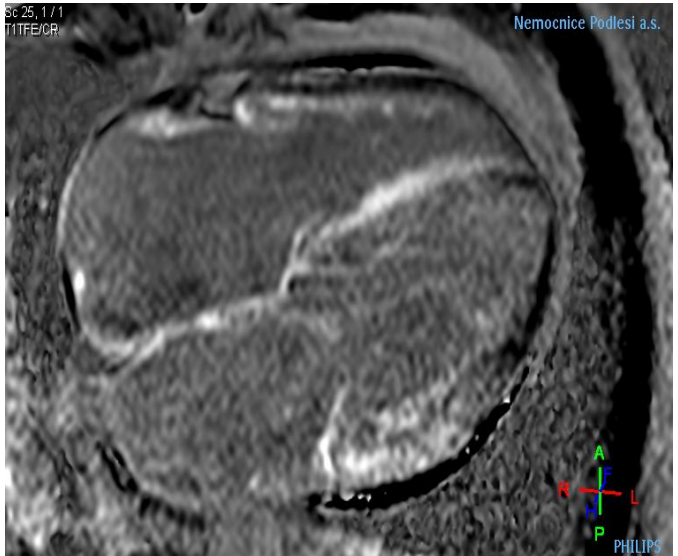
Shah et al. In: Edelman RR, et al., eds. *Clinical Magnetic Resonance Imaging.* 3rd ed. New York: Elsevier Press; 2005.

LGE


Sc 18, 1 / 1
T1TFE/CR
Vitkovicka nemocnice a.s.
PHILIPS

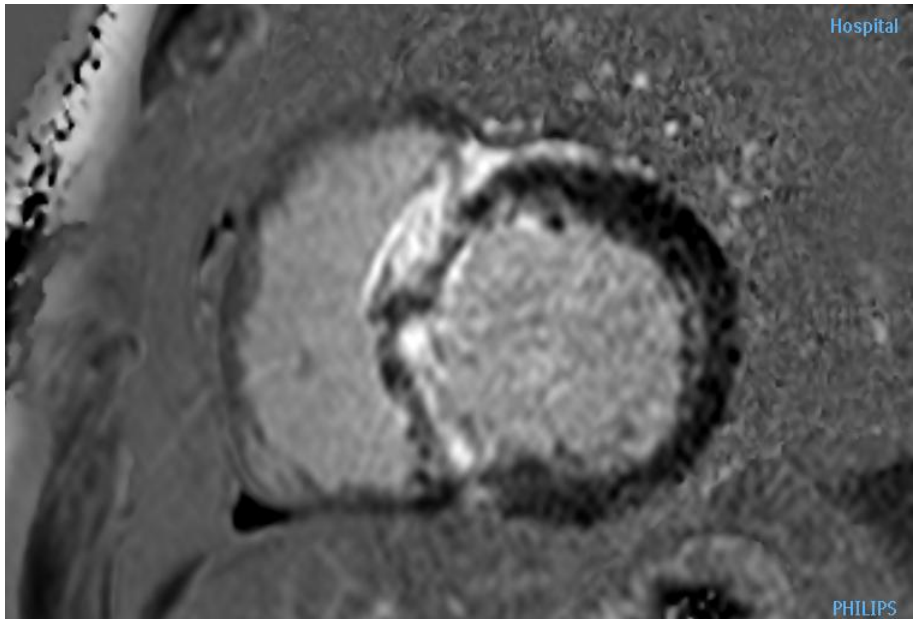

Sc 24, 1 / 4
T1TFE/CR
Nemocnice Podlesi a.s.
PHILIPS

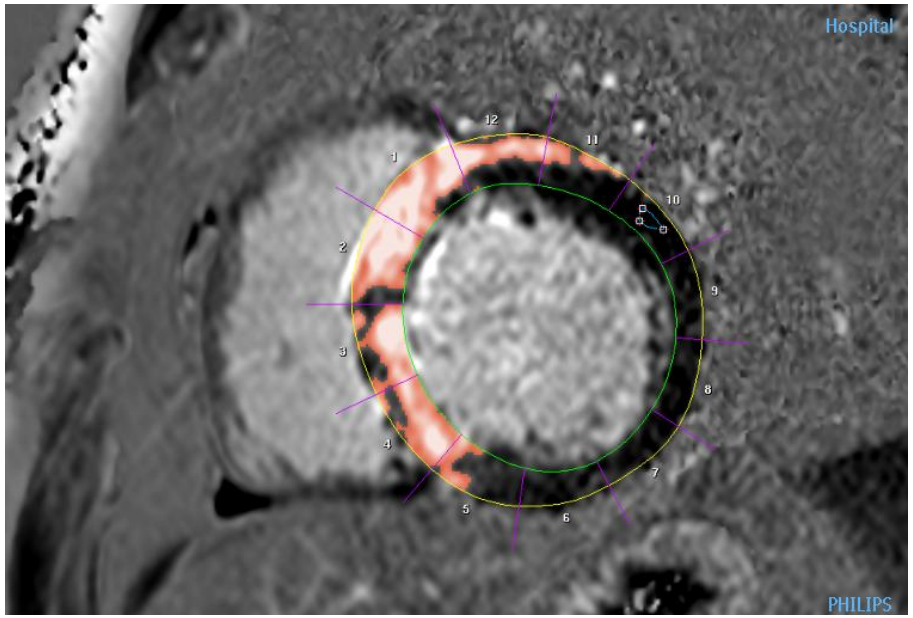

Sc 26, 1 / 3
T1TFE/CR
Vitkovicka nemocnice a.s.
PHILIPS


Sc 25, 1 / 1
T1TFE/CR
Nemocnice Podlesi a.s.
PHILIPS

Hodnocení LGE

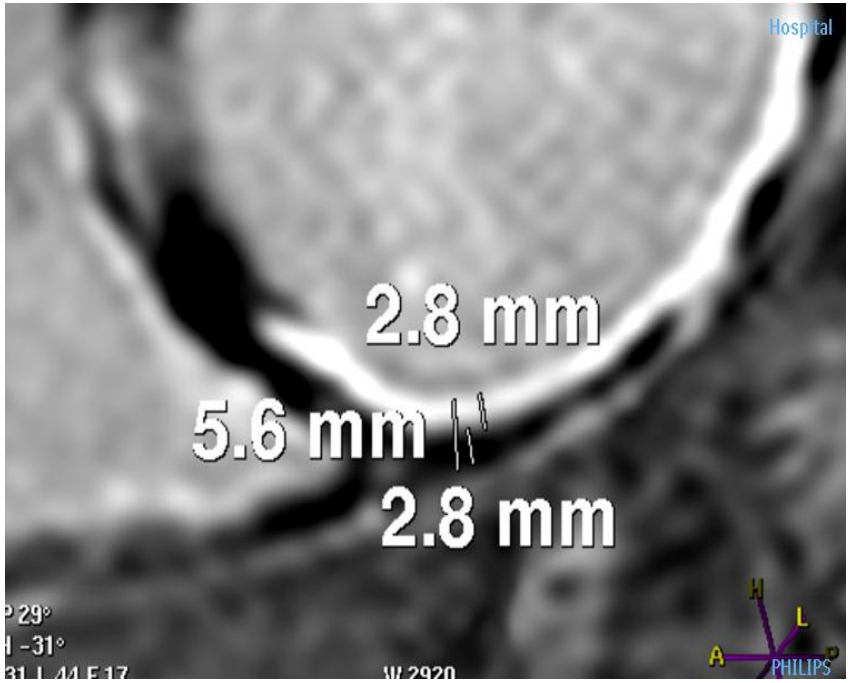
- lokalizace a charakter (fokální, difuzní atd.)
- ischemické x neischemické etiologie
- kvantifikace: pomocí „n“-SD (vizuální korekce)

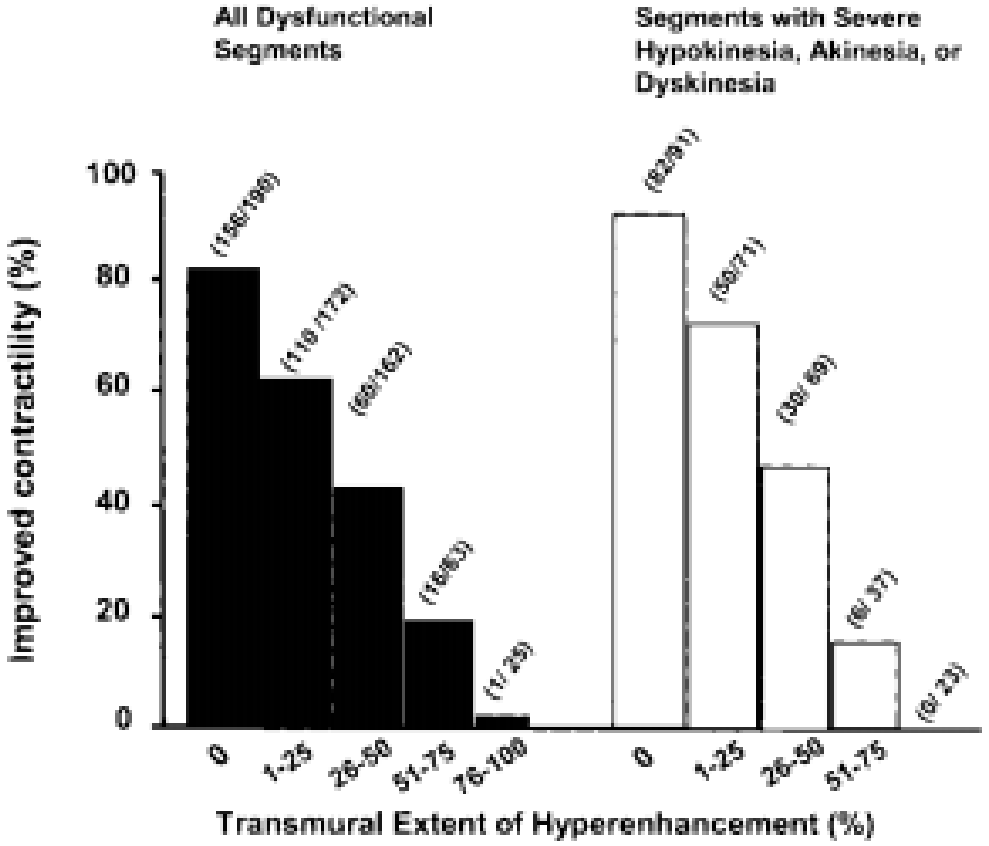




LGE – Index transmurality (IT)

- Cutt-off hodnota IT = 50 %



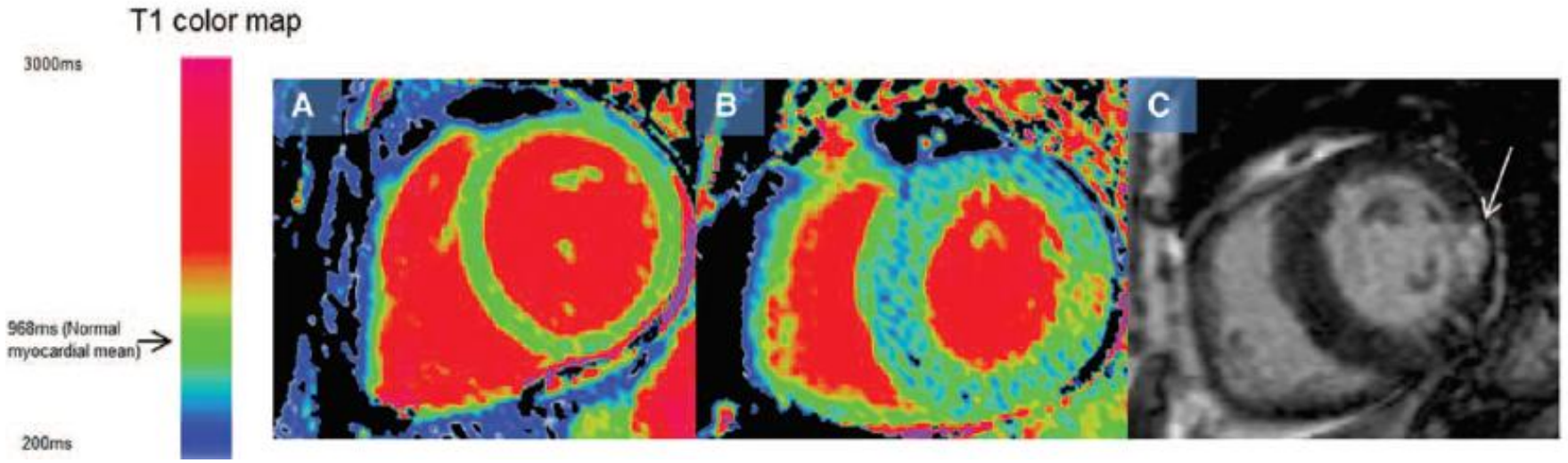


Selvanayagam JB et al. Value of delayed-enhancement cardiovascular magnetic resonance imaging in predicting myocardial viability after surgical revascularization. Circulation. 2004;110:1535-1541.

Tkáňová charakteristika myokardu LK

Parametrické sekvence

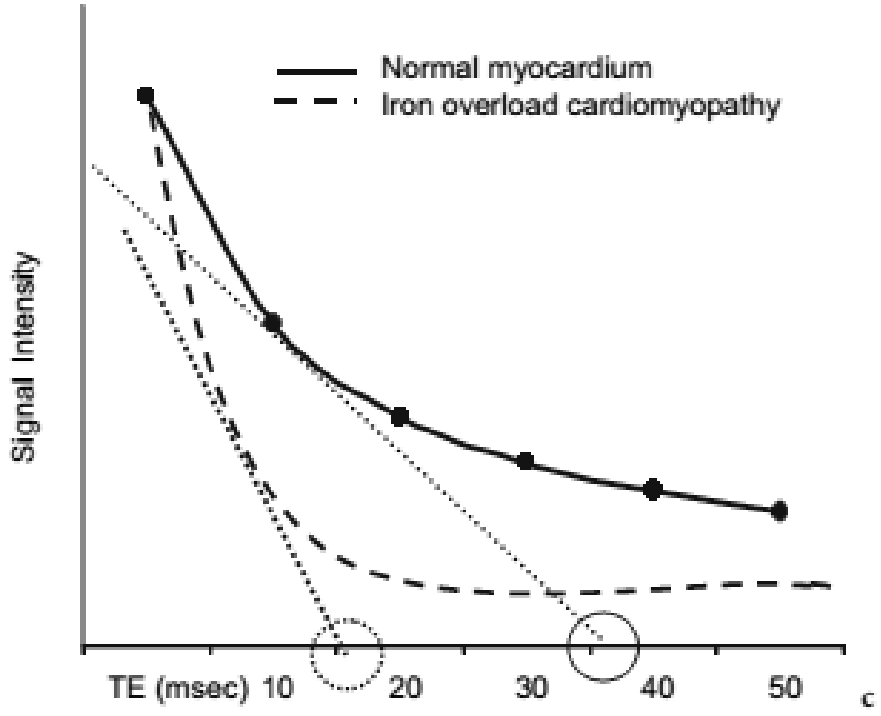
- T2*
- T1 mapping
- T2 mapping



Sado DM et al. Identification and Assessment of Anderson-Fabry Disease by Cardiovascular Magnetic Resonance Noncontrast Myocardial T1 Mapping. *Circ Cardiovasc Imaging*. 2013;6:392-398.

Hemochromatóza

- T2*– norma 33,3 ± 7,8 ms
- T2*< 20ms – zvýšené množství Fe v myokardu



Bogaert J, Dymarkowski S, Taylor AM (Eds.) *Clinical Cardiac MRI.* Berlin: Springer-Verlag Berlin Heidelberg, 2005.

T1 mapping

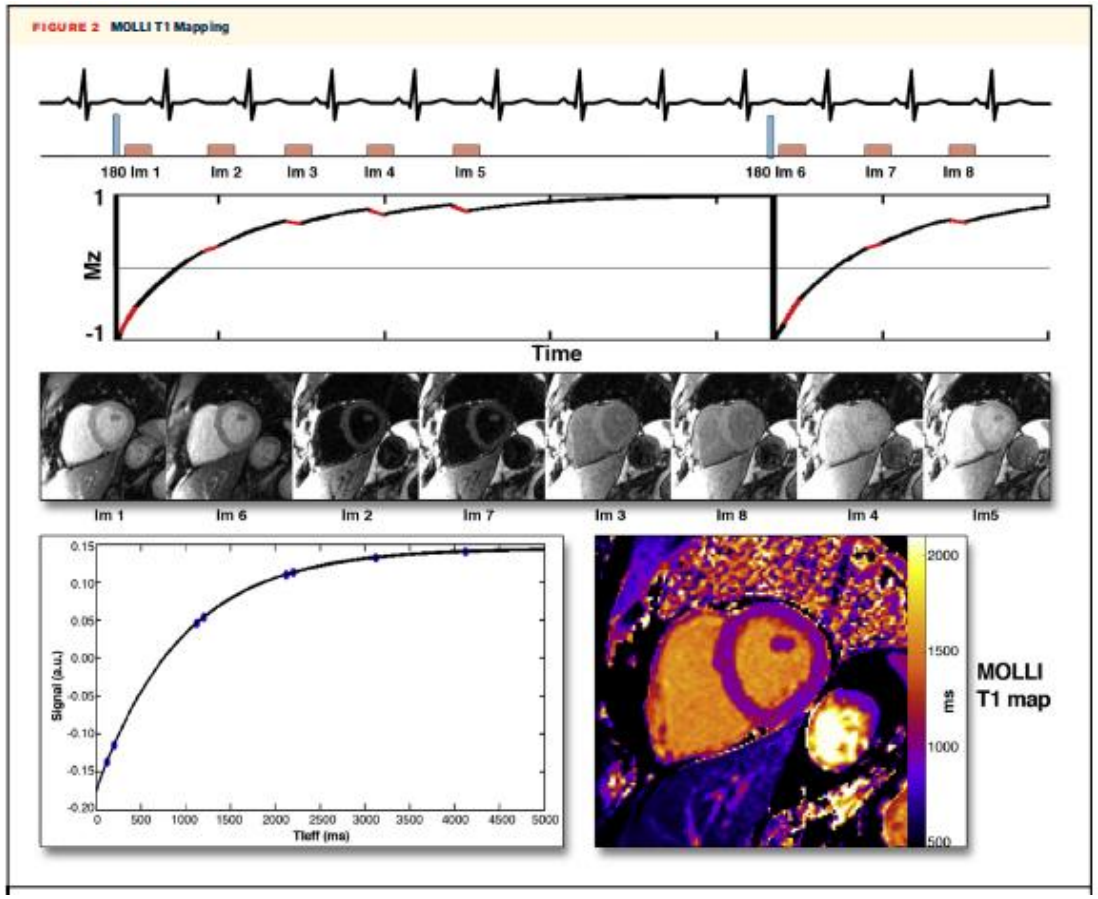
Předkontrastně:

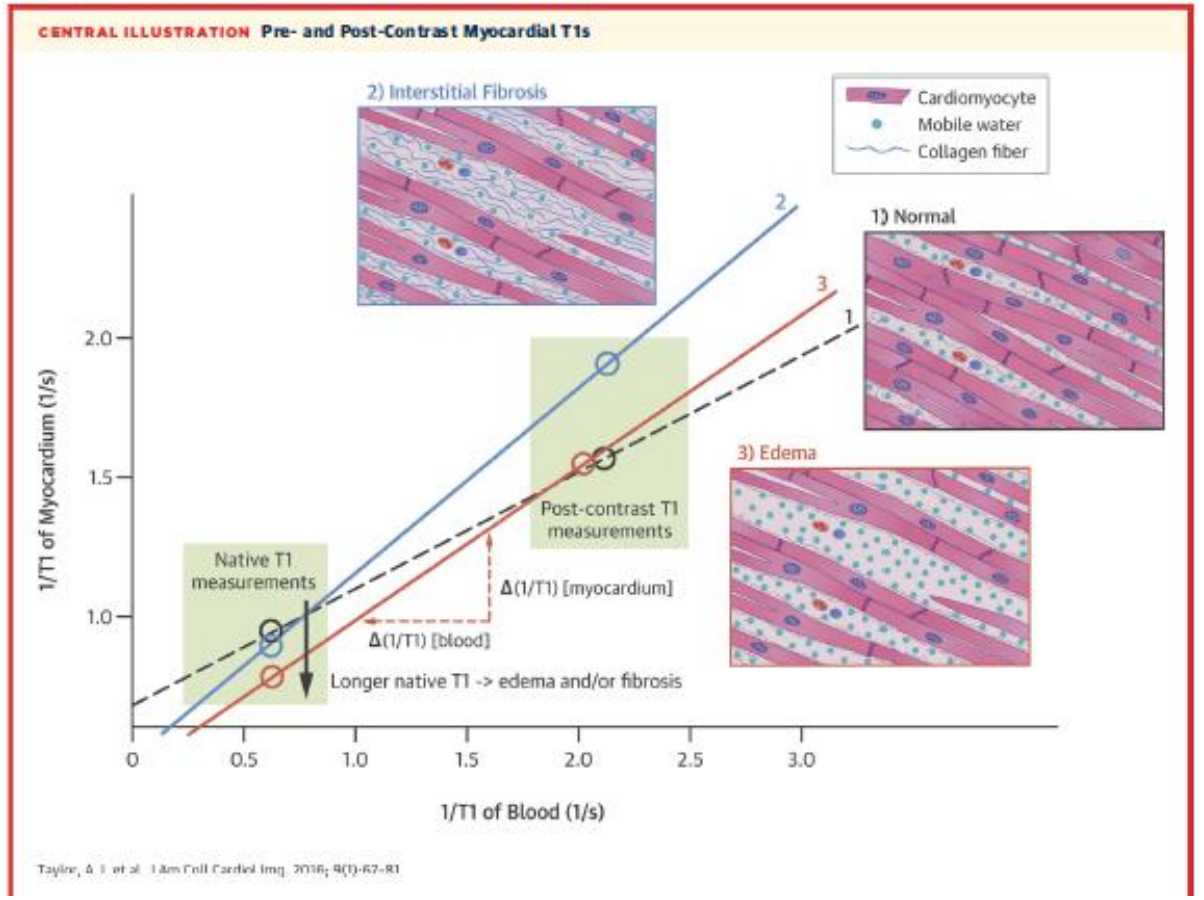
- přesné stanovení T1 relaxačního času myokardu
- 950 ± 21 ms (pro přístroje o síle 1,5 Tesla)
- zvýšení: edém myokardu, přítomnosti fibrózy či infiltrace amyloidem
- snížení: Fabryho choroba, sideróza

Postkontrastně:

- ECV (extracelulární objem/frakce): podíl extracelulárního objemu k celkovému objemu myokardu LK
- přítomnost fibrózy (difuzní) či amyloidu (nepoužívá se pro detekci edému).
- pro výpočet je nutné měřit T1 relaxační čas myokardu a krve před a 15 minut po podání kontrastní látky a také znát aktuální hodnotu hematokritu
- normální hodnota ECV je 0,25 ± 0,04 (1,5 Tesla)

T1 mapping

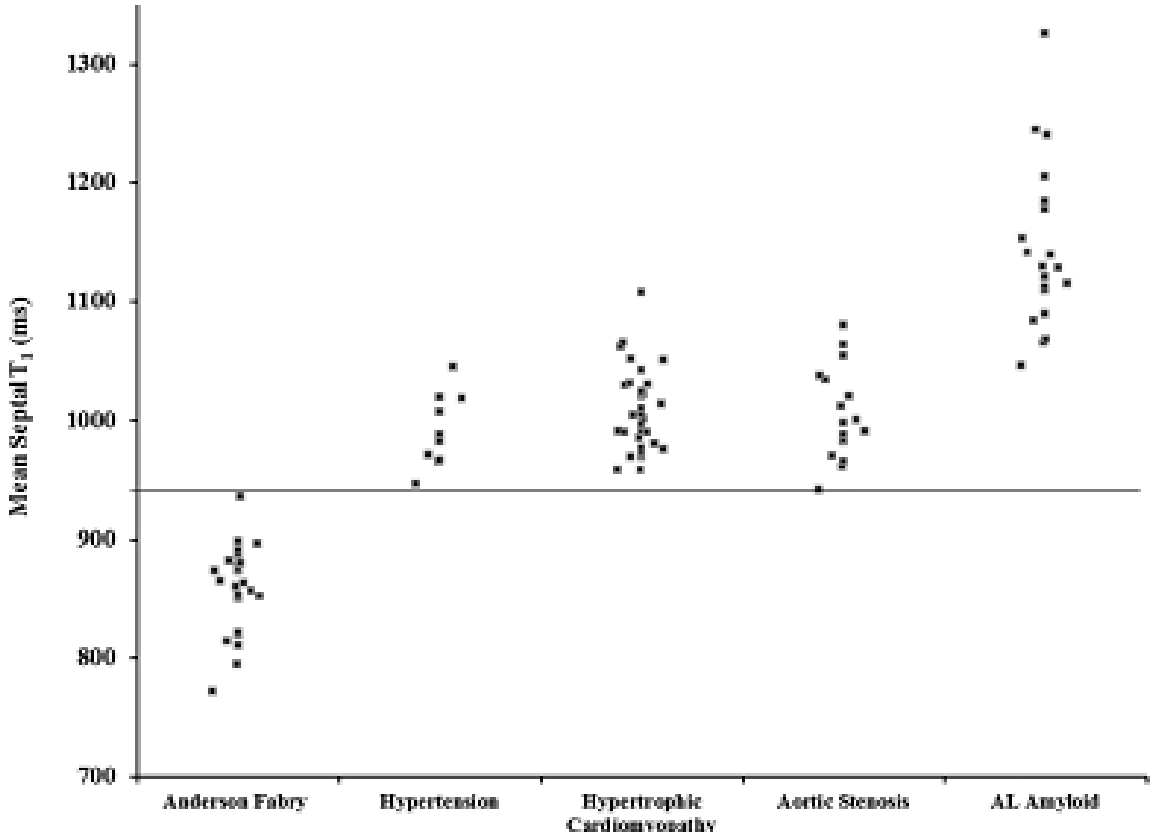




Taylor AJ et al. T1 Mapping Basic Techniques and Clinical Applications. JACC: CARDIOVASCULAR IMAGING CME. 2016;9(1):67-81.

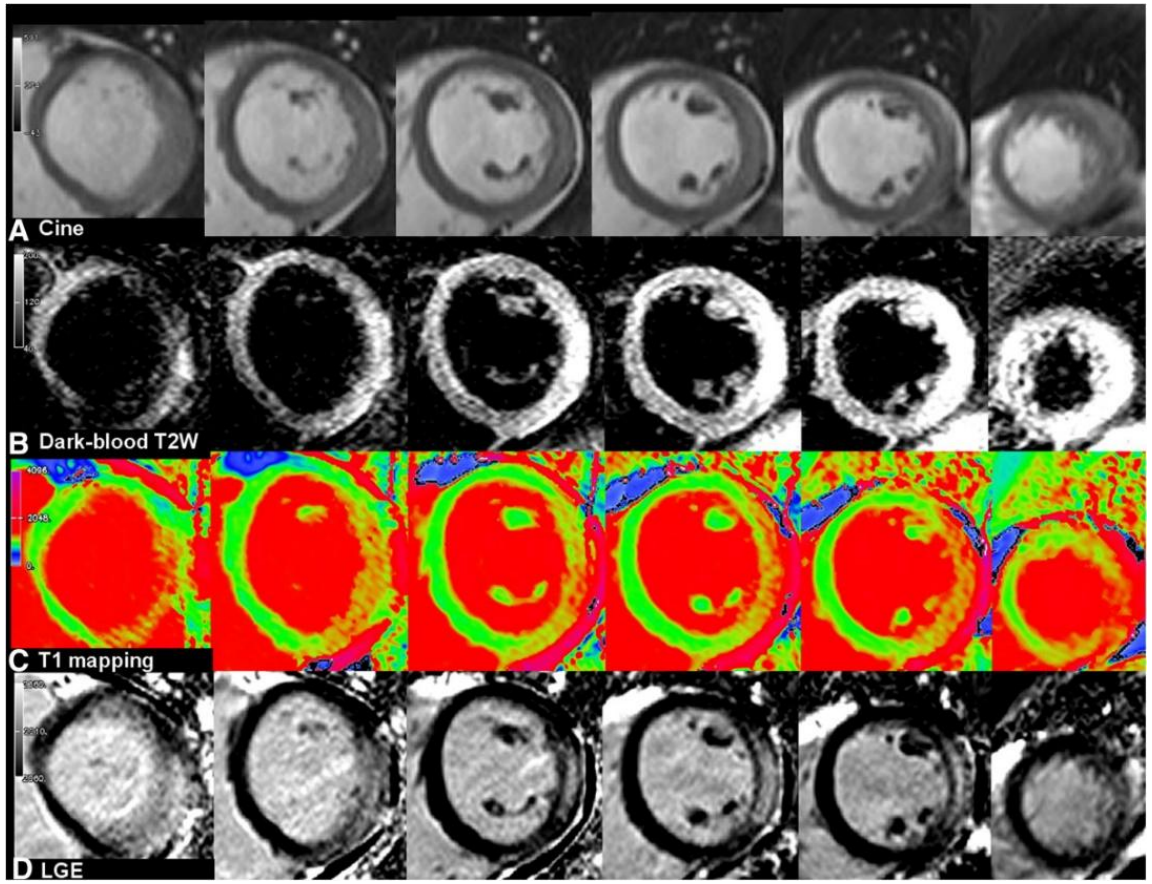
Identification and Assessment of Anderson-Fabry Disease by Cardiovascular Magnetic Resonance Noncontrast Myocardial T1 Mapping

Daniel M. Sado, MRCP; Steven K. White, MRCP; Stefan K. Piechnik, PhD;
Sanjay M. Banypersad, MRCP; Thomas Treibel, MRCP; Gabriella Captur, MRCP;
Marianna Fontana, MD; Viviana Maestrini, MD; Andrew S. Flett, MD; Matthew D. Robson, PhD;
Robin H. Lachmann, PhD, FRCP; Elaine Murphy, FRCPath; Atul Mehta, FRCP;
Derralynn Hughes, DPhil; Stefan Neubauer, MD; Perry M. Elliott, MD; James C. Moon, MD



Circ Cardiovasc Imaging. 2013;6:392-398

T1 mapping



Ferreira VM et al. Native T1-mapping detects the location, extent and patterns of acute myocarditis without the need for gadolinium contrast agents. *Journal of Cardiovascular Magnetic Resonance*. 2014;16:36.

T1 mapping

Table 2 Diagnostic performance of CMR tissue characterization methods in the detection of suspected acute myocarditis

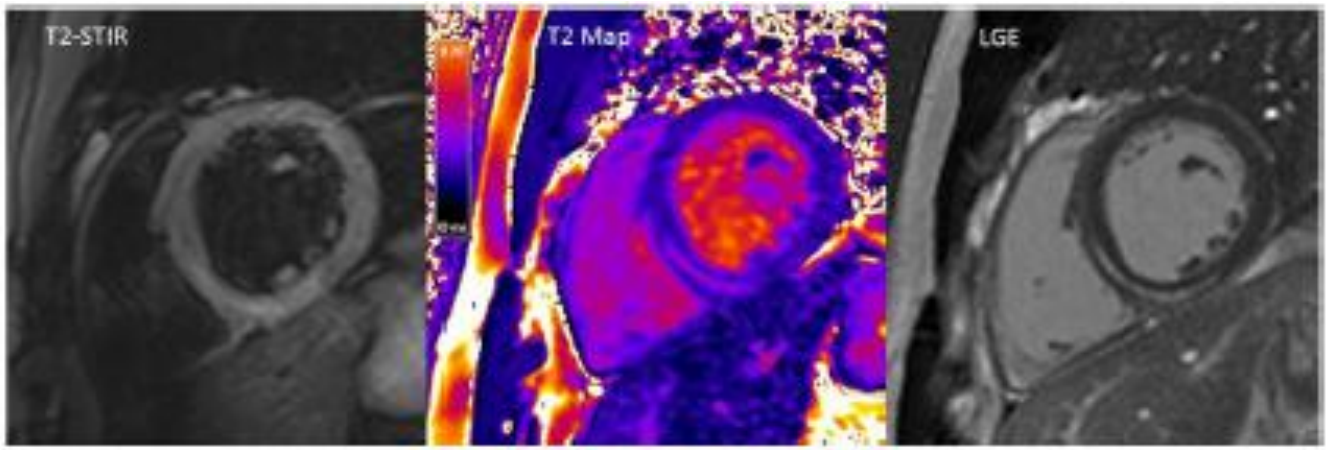
Tissue criteria	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
Individual					
T1-mapping*	90	88	89	90	88
Dark-blood T2*	48	86	66	81	58
LGE	72	97	81	98	67
Combination (with LGE)					
Dark-blood T2 and LGE (2 out of 2)†‡	45	97	64	96	51
Dark-blood T2 or LGE (Any 1 of 2)	75	86	79	90	67
T1-mapping and LGE (2 out of 2)†	67	97	78	98	63
T1-mapping or LGE (Any 1 of 2)	95	83	91	91	91
T1-mapping, dark-blood T2 or LGE (Any 1 of 3)	95	71	86	85	89
T1-mapping, dark-blood T2 or LGE (Any 2 of 3)	70	97	80	98	65
T1-mapping and dark-blood T2 and LGE (3 out of 3)	45	97	64	96	51
Combination (without LGE)					
T1-mapping and dark-blood T2 (2 out of 2)‡	48	98	71	97	61
T1-mapping or dark-blood T2 (Any 1 of 2)	90	76	84	82	86

*statistically different ($p < 0.05$); †‡no statistical difference ($p = ns$). T1-mapping: myocardial injury is detected when T1 is ≥ 990 ms; Dark-blood T2-weighted imaging: edema is diagnosed when the T2 SI ratio ($T2\ SI_{myocardium\ :\ skeletal\ muscle}$) is ≥ 2:1; Late gadolinium enhancement (LGE) is detected when myocardial SI is ≥ 2 SD above mean SI of remote myocardium. For each technique, only contiguous areas of myocardium ≥40 mm^2 above the stated threshold were considered relevant; involvement of ≥5% of any segment on a per-subject basis was the threshold used for comparison of methods. PPV = positive predictive value; NPV = negative predictive value.

Ferreira VM et al. Native T1-mapping detects the location, extent and patterns of acute myocarditis without the need for gadolinium contrast agents. *Journal of Cardiovascular Magnetic Resonance*. 2014;16:36.

T2 mapping

- T2 relaxační čas < 60 ms
- využití stejné jako pro T2W obrazy
- přesnější v diagnostice zánětlivé KMP
- *akutní rejekce*
- *kardiotoxicita chemoterapie*



Lota AS et al. T2 mapping and T2* imaging in heart failure. Heart Fail Rev. 2017;22:431–440.

MRI hodnocení LK

Standardní hodnocení:

- velikost a systolická funkce
- hypertrofie stěn (charakter)
- regionální poruchy kinetiky
- signálové změny myokardu LK
  - předkontrastní (edém…)
  - postkontrastní (LGE)

Nadstandardní hodnocení:

- strain rate (tagging, feature tracking)
- parametrické metody
  - T2*
  - T1 mapping
  - T2 mapping

Odborné stanovisko

Indikační kritéria MRI srdce a jejich časový harmonogram

Společné odborné stanovisko České kardiologické společnosti a Radiologické společnosti České lékařské společnosti Jana Evangelisty Purkyně

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[8]Klinika radiologie a nukleární medicíny, Fakultní nemocnice Brno a Lékařská fakulta Masarykovy univerzity, Brno

Mezioborové sympozium nad srdeční tomografií

30.3.2019, FN Motol, Praha

Děkuji Vám za pozornost