Kritický pohled na...
TRIPLE RULE OUT CT

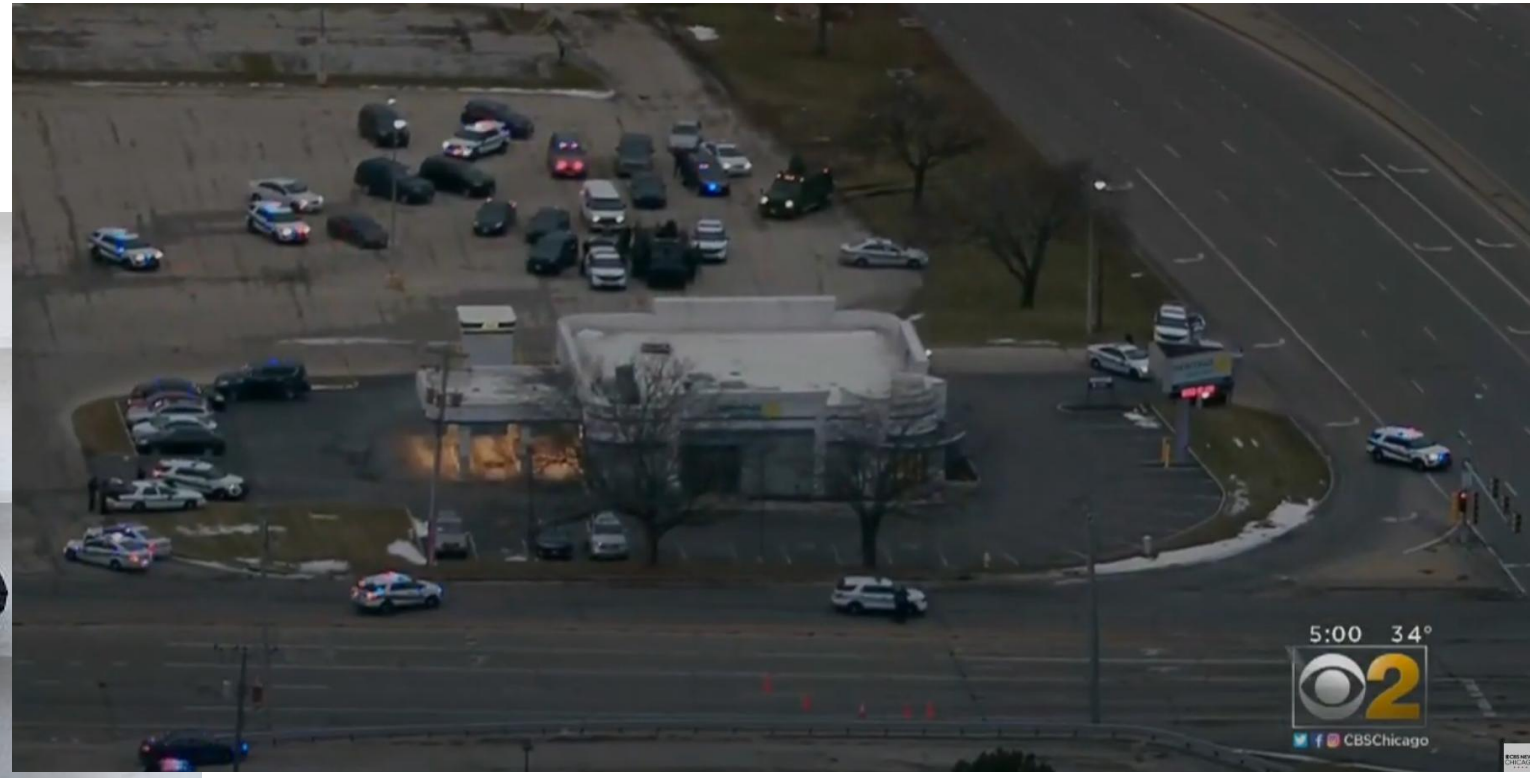
Vladimír Černý
RDG VFN Praha

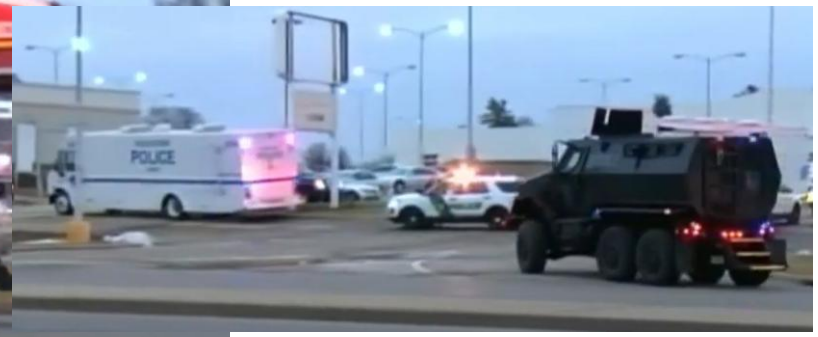
Triple rule out CT

- Obstruktivní koronární nemoc
- Disekce aorty
- Plicní embolie

- Jiné nálezy
  - myokarditis?, perikarditis
  - spondylodiscitis, pleuritis, …

- Jedno CT vyšetření (ideálně jedna fáze)





https://www.denik.cz/krimi/udajna-bankovni-loupez-v-brne-policiste-zasahovali-v-masarykove-ulici-20171214.html

https://www.youtube.com/watch?v=AfPkHnbJfCE

Technické parametry

Nad| Triple-Rule-Out CT Angiography for Evaluation of Acute Chest Pain and Possible Acute Coronary Syndrome[1]

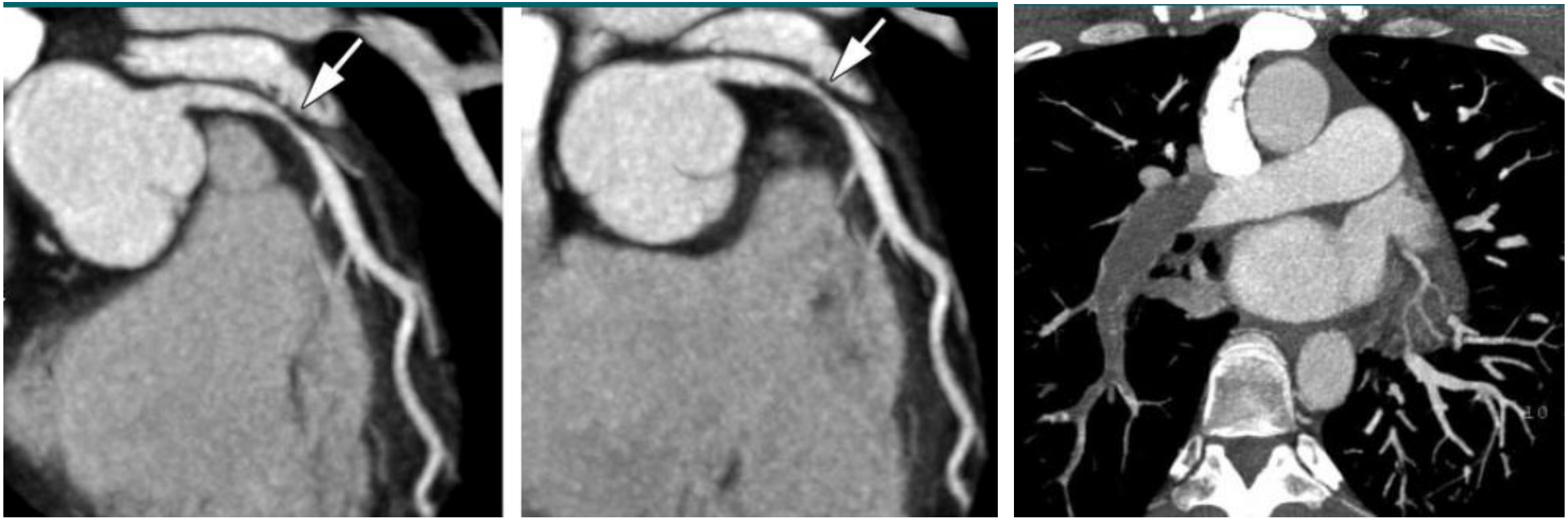
Radiology

- Radiology 2009

- 64-řadé CT
- Omezený kraniokaudální rozsah
- Retrospektivní EKG synchroizace
- 18 mSv

Halpern EJ. Triple-rule-out CT angiography for evaluation of acute chest pain and possible acute coronary syndrome. Radiology. 2009 Aug;252(2):332-45. doi: 10.1148/radiol.2522082335. PMID: 19703877.

Nadpis



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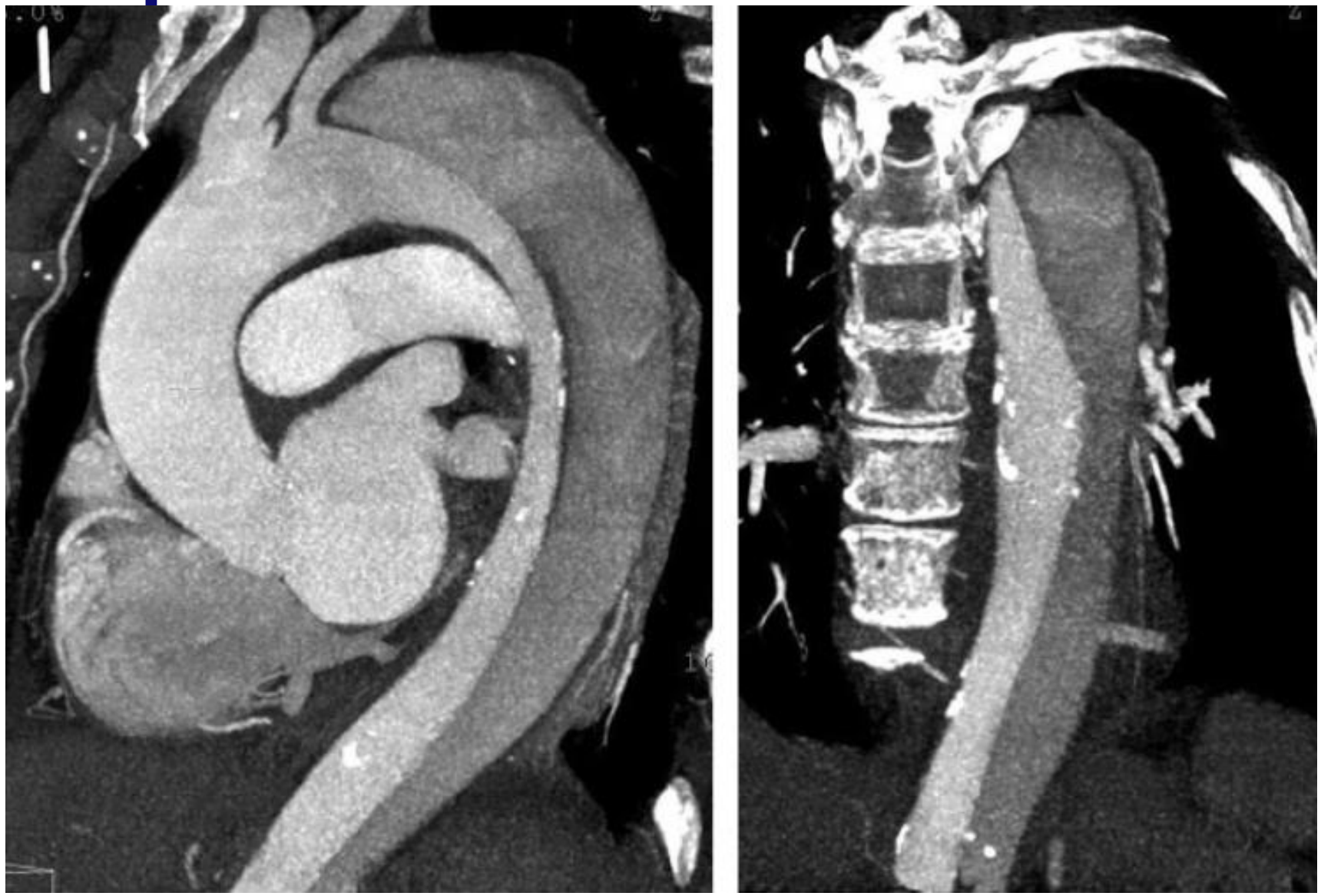

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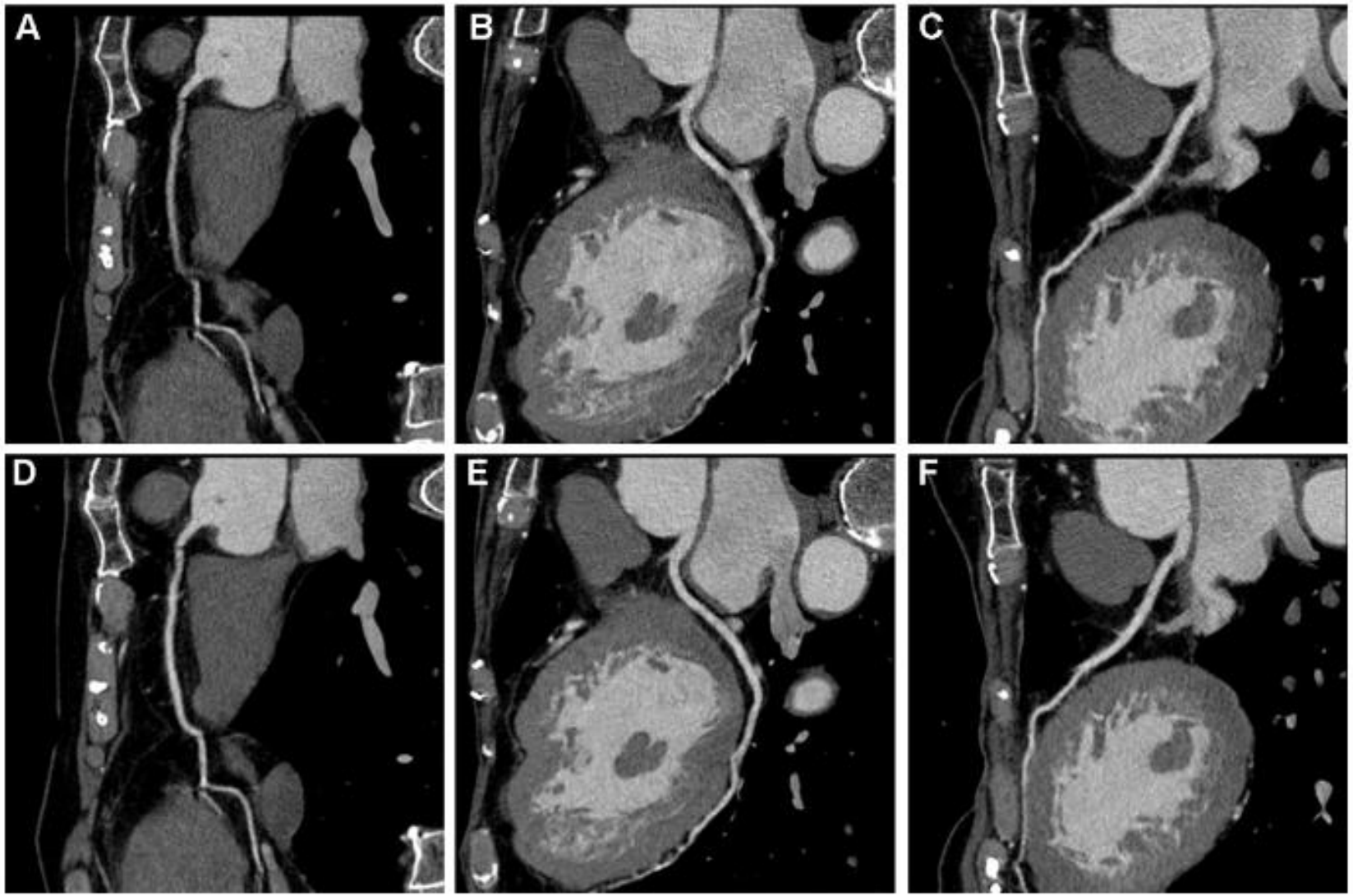
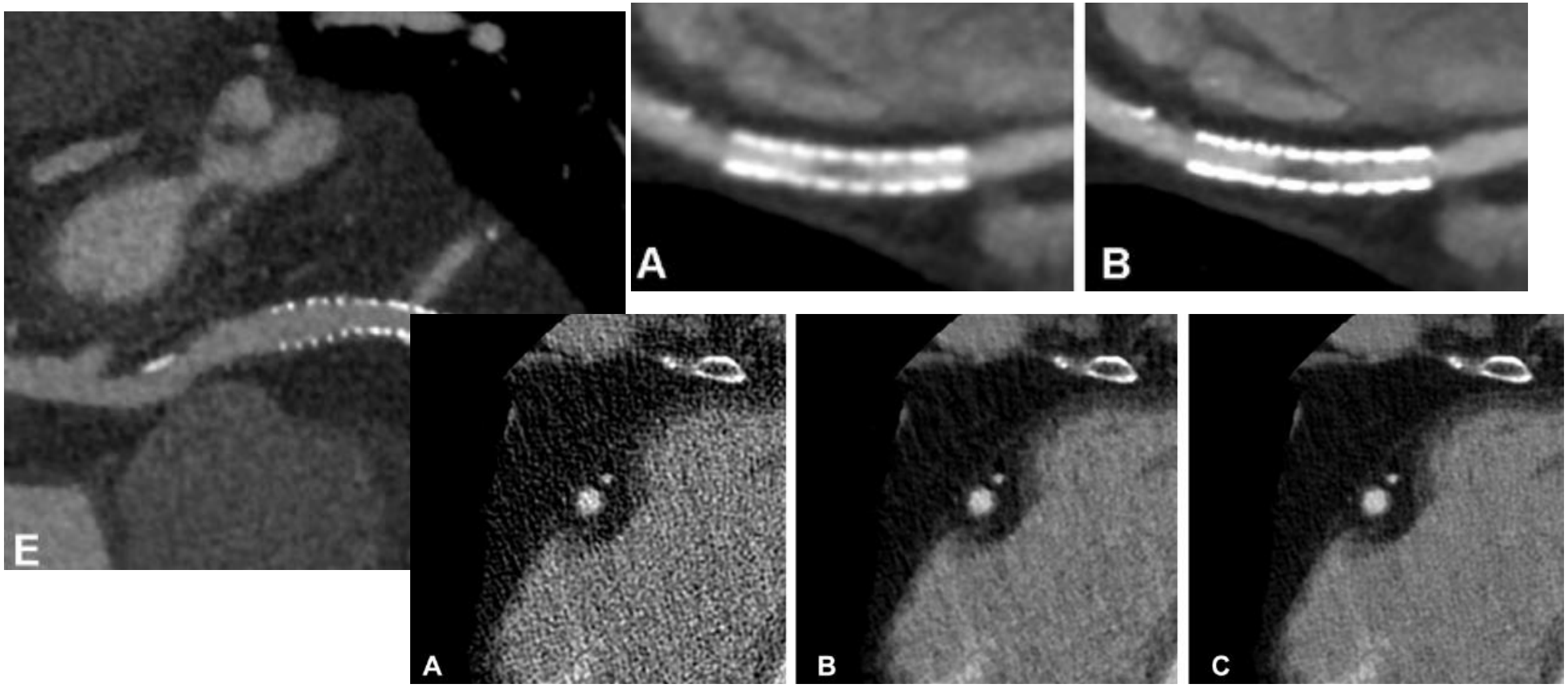


Fukui R, Harashima S, Samejima W, Shimizu Y, Washizuka F, Kariyasu T, Nishikawa M, Yamaguchi H, Takeuchi H, Machida H. Acquisition and Reconstruction Techniques for Coronary CT Angiography: Current Status and Trends over the Past Decade. Radiographics. 2025 Jul;45(7):e240083. doi: 10.1148/rg.240083. PMID: 40504731.



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Radiology

ORIGINAL RESEARCH • CARDIAC IMAGING

Accuracy of Ultrahigh-Resolution Photon-counting CT for Detecting Coronary Artery Disease in a High-Risk Population

- TAVI protokol
- Retrospektivní EKG synchronizace na oblast srdce
- 13,3 mSv

Hagar MT, Soschynski M, Saffar R, Rau A, Taron J, Weiss J, Stein T, Faby S, von Zur Muehlen C, Ruile P, Schlett CL, Bamberg F, Krauss T. Accuracy of Ultrahigh-Resolution Photon-counting CT for Detecting Coronary Artery Disease in a High-Risk Population. Radiology. 2023 Jun;307(5):e223305. doi: 10.1148/radiol.223305. PMID: 37338354.

Radiology

ORIGINAL RESEARCH • CARDIAC IMAGING

Accuracy of Ultrahigh-Resolution Photon-counting CT for Detecting Coronary Artery Disease in a High-Risk Population

- Nediagnostických segmentů
  - lumen ≥1,5 mm **2,2 %**
- Agatson skóre ≥ 1000
  - Přesnost detekce CAD ≥ 70 %: **71 %**
- Přítomnost stentů
  - Přesnost detekce CAD ≥ 70 %: **87 %**

Hagar MT, Soschynski M, Saffar R, Rau A, Taron J, Weiss J, Stein T, Faby S, von Zur Muehlen C, Ruile P, Schlett CL, Bamberg F, Krauss T. Accuracy of Ultrahigh-Resolution Photon-counting CT for Detecting Coronary Artery Disease in a High-Risk Population. Radiology. 2023 Jun;307(5):e223305. doi: 10.1148/radiol.223305. PMID: 37338354.

Triple Rule Out CT in the Emergency Department: Clinical Risk and Outcomes (Triple Rule Out in the Emergency Department)

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- 2021-2022
- 1279 pacientů
- 128/192 řadé CT, dual source
- Rozsah celého hrudníku
- Retrospektivní EKG synchronizace
- 23.8 ± 12 mSv

Araoz PA, Gadam S, Bhanushali AK, Sharma P, Singh M, Mullan AF, Collins JD, Young PM, Kopecky S, Clements CM. Triple Rule Out CT in the Emergency Department: Clinical Risk and Outcomes (Triple Rule Out in the Emergency Department). Acad Radiol. 2025 Mar;32(3):1297-1305. doi: 10.1016/j.acra.2024.10.051. Epub 2024 Dec

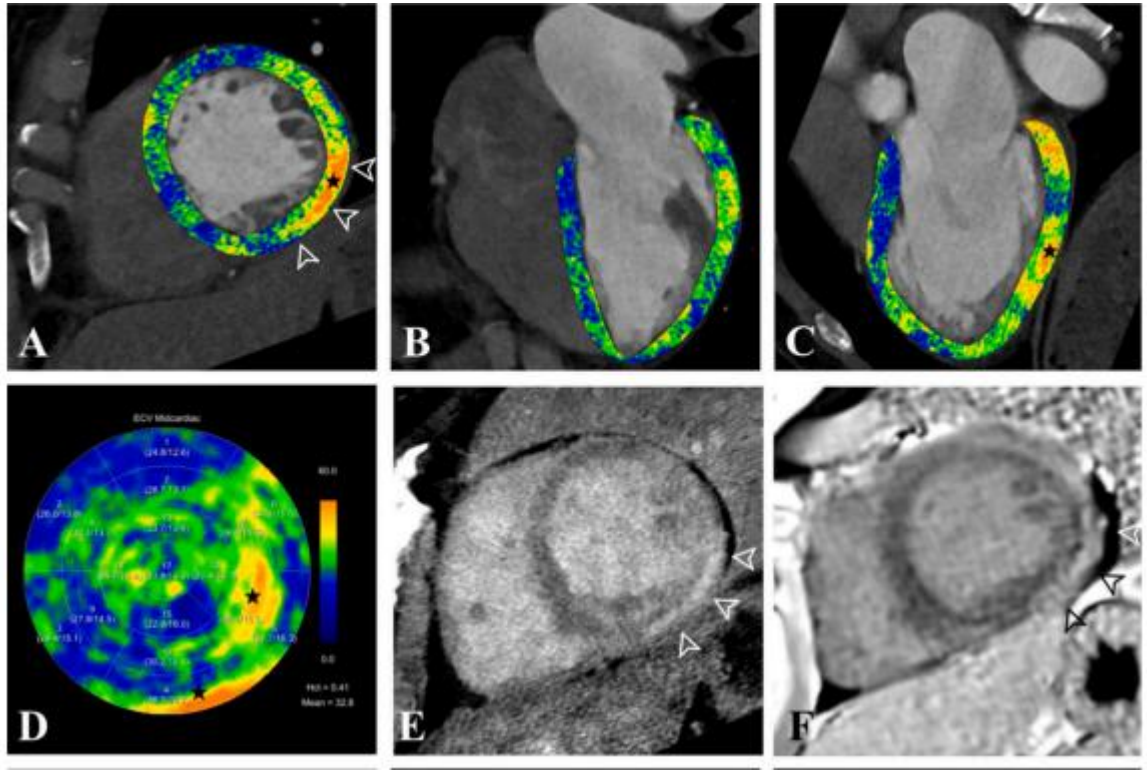
Original article

Photon-counting CT-derived extracellular volume in acute myocarditis: Comparison with cardiac MRI

Christos Gkizas [a,*], Benjamin Longere [a,b], Olga Sliwicka [a], Aimee Rodriguez Musso [a], Gilles Lemesle [b,c], Cedric Croisille [d], Mehdi Haidar [a], Francois Pontana [a,b]

- 32 pacientů s podezřením na akutní myokarditis
- CCTA
- LIE skeny (1,23 mSv)

- CT-ECV
  - 31,7 myokarditis
  - 25,6 normální nález
- Silná korelace CT-ECV a MR-ECV (r 0.95)



Gkizas C, Longere B, Sliwicka O, Musso AR, Lemesle G, Croisille C, Haidar M, Pontana F. Photon-counting CT-derived extracellular volume in acute myocarditis: Comparison with cardiac MRI. Diagn Interv Imaging. 2025 Jul-Aug;106(7-8):255-263. doi: 10.1016/j.diii.2025.03.001. Epub 2025 Mar 18. PMID: 40102107.

Personální zabezpečení

SCCT guidelines on the use of coronary computed tomographic angiography for patients presenting with acute chest pain to the emergency department: A Report of the Society of Cardiovascular Computed Tomography Guidelines Committee

Gilbert L. Raff MD[a,*], Kavitha M. Chinnaiyan MD[a], Ricardo C. Cury MD[b], Mario T. Garcia MD[c], Harvey S. Hecht MD[d], Judd E. Hollander MD[e], Brian O'Neil MD[f], Allen J. Taylor MD[g], Udo Hoffmann MD[h]

Raff GL, Chinnaiyan KM, Cury RC, Garcia MT, Hecht HS, Hollander JE, O'Neil B, Taylor AJ, Hoffmann U; Society of Cardiovascular Computed Tomography Guidelines Committee. SCCT guidelines on the use of coronary computed tomographic angiography for patients presenting with acute chest pain to the emergency department: a report of the Society of Cardiovascular Computed Tomography Guidelines Committee. J Cardiovasc Comput Tomogr. 2014 Jul-Aug;8(4):254-71. doi: 10.1016/j.jcct.2014.06.002. Epub 2014 Jun 12. PMID: 25151918.

Personální obsazení

- Radiologický asistent ≥ 100 CT koronarografií
- Sestra / ACLS certifikovaný asistent
- Radiolog ≥ 300 popsaných CT koronarografií

Raff GL, Chinnaiyan KM, Cury RC, Garcia MT, Hecht HS, Hollander JE, O'Neil B, Taylor AJ, Hoffmann U; Society of Cardiovascular Computed Tomography Guidelines Committee. SCCT guidelines on the use of coronary computed tomographic angiography for patients presenting with acute chest pain to the emergency department: a report of the Society of Cardiovascular Computed Tomography Guidelines Committee. J Cardiovasc Comput Tomogr. 2014 Jul-Aug;8(4):254-71. doi: 10.1016/j.jcct.2014.06.002. Epub 2014 Jun 12. PMID: 25151918.

Výhody Triple Rule Out

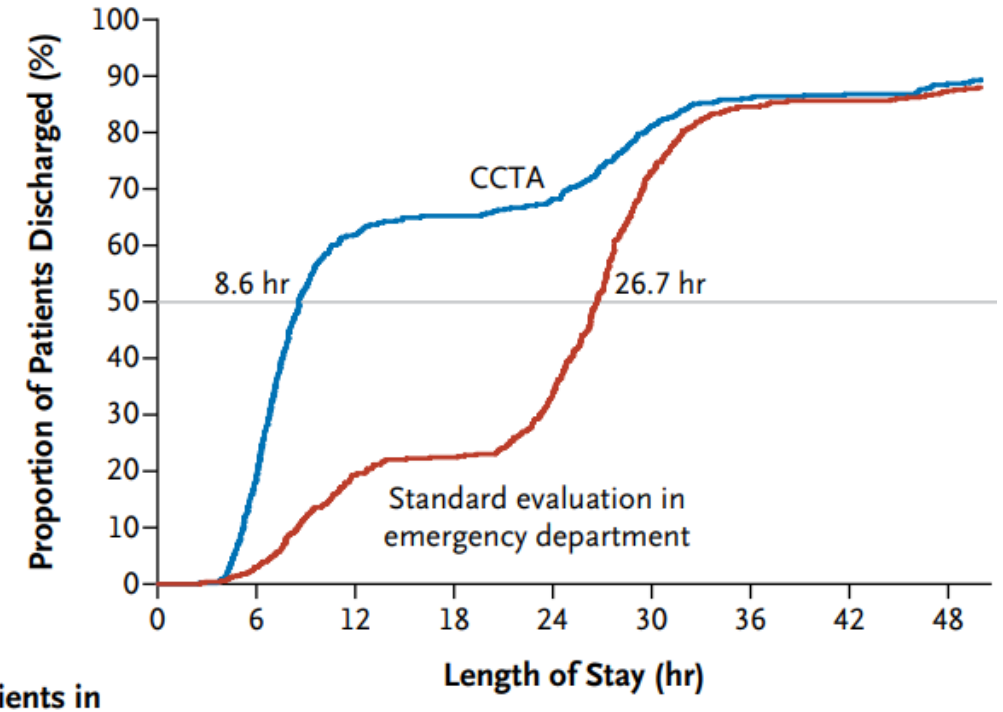
Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain

- ROMICAT II studie

- 1000 pacientů, 501 CCTA 499 standardní režim
- Bez „ischemického nálezu“ na EKG
- Negativní iniciální troponin

Hoffmann U, Truong QA, Schoenfeld DA, Chou ET, Woodard PK, Nagurney JT, Pope JH, Hauser TH, White CS, Weiner SG, Kalanjian S, Mullins ME, Mikati I, Peacock WF, Zakroysky P, Hayden D, Goehler A, Lee H, Gazelle GS, Wiviott SD, Fleg JL, Udelson JE; ROMICAT-II Investigators. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med. 2012 Jul 26;367(4):299-308. doi: 10.1056/NEJMoa1201161. PMID: 22830462; PMCID: PMC3662217.

Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain



No. of Patients in Emergency Department or Hospital									
CCTA	501	404	191	174	159	95	70	66	57
Standard evaluation	499	484	403	387	331	135	77	72	63

Hoffmann U, Truong QA, Schoenfeld DA, Chou ET, Woodard PK, Nagurney JT, Pope JH, Hauser TH, White CS, Weiner SG, Kalanjian S, Mullins ME, Mikati I, Peacock WF, Zakroysky P, Hayden D, Goehler A, Lee H, Gazelle GS, Wiviott SD, Fleg JL, Udelson JE; ROMICAT-II Investigators. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med. 2012 Jul 26;367(4):299-308. doi: 10.1056/NEJMoa1201161. PMID: 22830462; PMCID: PMC3662217.

Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain

	CCTA (N=501)	Standard Evaluation (N=499)	
Discharge status — no. (%)			<0.001
Direct discharge from emergency department	233 (47)	62 (12)	
Admission to observation unit	153 (30)	301 (60)	
Admission to hospital	107 (21)	125 (25)	
Left against medical advice	8 (2)	11 (2)	

Hoffmann U, Truong QA, Schoenfeld DA, Chou ET, Woodard PK, Nagurney JT, Pope JH, Hauser TH, White CS, Weiner SG, Kalanjian S, Mullins ME, Mikati I, Peacock WF, Zakroysky P, Hayden D, Goehler A, Lee H, Gazelle GS, Wiviott SD, Fleg JL, Udelson JE; ROMICAT-II Investigators. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med. 2012 Jul 26;367(4):299-308. doi: 10.1056/NEJMoa1201161. PMID: 22830462; PMCID: PMC3662217.

Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain

	CCTA (N=501)	Standard Evaluation (N=499)	
Follow-up for recurrent chest pain within 28 days — no.			
Repeat visit to emergency department	14	19	0.38
Repeat hospitalization	7	7	
Safety — no.			
Undetected acute coronary syndrome	0	0	
Periprocedural complications	2	0	0.50
Major adverse cardiovascular events at 28 days — no.	2	6	0.18

Hoffmann U, Truong QA, Schoenfeld DA, Chou ET, Woodard PK, Nagurney JT, Pope JH, Hauser TH, White CS, Weiner SG, Kalanjian S, Mullins ME, Mikati I, Peacock WF, Zakroysky P, Hayden D, Goehler A, Lee H, Gazelle GS, Wiviott SD, Fleg JL, Udelson JE; ROMICAT-II Investigators. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med. 2012 Jul 26;367(4):299-308. doi: 10.1056/NEJMoa1201161. PMID: 22830462; PMCID: PMC3662217.

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- 1279 pacientů
- 65 % riziko ≥ 2 diagnóz

- 48 % propuštěno z ED

- 28 akutní infarkt
- 91 plicní embolie (1 falešně pozitivní)
- 7 akutní aortální syndrom

- 84 jiné kardiální onemocnění
- 244 plicní onemocnění

Araoz PA, Gadam S, Bhanushali AK, Sharma P, Singh M, Mullan AF, Collins JD, Young PM, Kopecky S, Clements CM. Triple Rule Out CT in the Emergency Department: Clinical Risk and Outcomes (Triple Rule Out in the Emergency Department). Acad Radiol. 2025 Mar;32(3):1297-1305. doi: 10.1016/j.acra.2024.10.051. Epub 2024 Dec

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- 1279 pacientů
- Dostupnost 24/7 (*)
- Hodnocení:
  - Pracovní dny „kardioradiolog“
  - ÚPS: radiologický rezident, druhé čtení druhý den ráno

Araoz PA, Gadam S, Bhanushali AK, Sharma P, Singh M, Mullan AF, Collins JD, Young PM, Kopecky S, Clements CM. Triple Rule Out CT in the Emergency Department: Clinical Risk and Outcomes (Triple Rule Out in the Emergency Department). Acad Radiol. 2025 Mar;32(3):1297-1305. doi: 10.1016/j.acra.2024.10.051. Epub 2024 Dec

Interpretace triple-rule-out

Emergency Radiology (2021) 28:735–742
https://doi.org/10.1007/s10140-021-01911-8

ORIGINAL ARTICLE

The triple rule out CT in acute chest pain: a challenge for emergency radiologists?

- 350 pacientů
- „Kardioradiolog“, Senior, **Junior**
- Shoda
  - 100 % v detekci PE i AAS
  - 90-97 % v detekci neobstruktivní CAD
  - 88%, 85%, **71 %** v detekci obstruktivní CAD

Russo V, Sportoletti C, Scalas G, Attinà D, Buia F, Niro F, Modolon C, De Luca C, Monteduro F, Lovato L. The triple rule out CT in acute chest pain: a challenge for emergency radiologists? Emerg Radiol. 2021 Aug;28(4):735-742. doi: 10.1007/s10140-021-01911-8. Epub 2021 Feb 18. PMID: 33604768; PMCID: PMC8280047.

Nevýhody Triple Rule Out

Triple Rule Out Versus Coronary CT Angiography in Patients With Acute Chest Pain

Results From the ACIC Consortium

Alfred C. Burris II, MD, Judith A. Boura, MS, Gilbert L. Raff, MD, Kavitha M. Chinnaiyan, MD

- 1555 TRO
- 11279 CCTA
- TRO – 57 % žen

- *Radiace*
  - TRO 9 mSv
  - CCTA 6,2 mSv
- *Nediagnostické skeny*
  - TRO 9,4 %
  - CCTA 6,5 %

Burris AC 2nd, Boura JA, Raff GL, Chinnaiyan KM. Triple Rule Out Versus Coronary CT Angiography in Patients With Acute Chest Pain: Results From the ACIC Consortium. JACC Cardiovasc Imaging. 2015 Jul;8(7):817-25. doi: 10.1016/j.jcmg.2015.02.023. Epub 2015 Jun 17. PMID: 26093928.

Triple Rule Out Versus Coronary CT Angiography in Patients With Acute Chest Pain

Results From the ACIC Consortium

Alfred C. Burris II, MD, Judith A. Boura, MS, Gilbert L. Raff, MD, Kavitha M. Chinnaiyan, MD

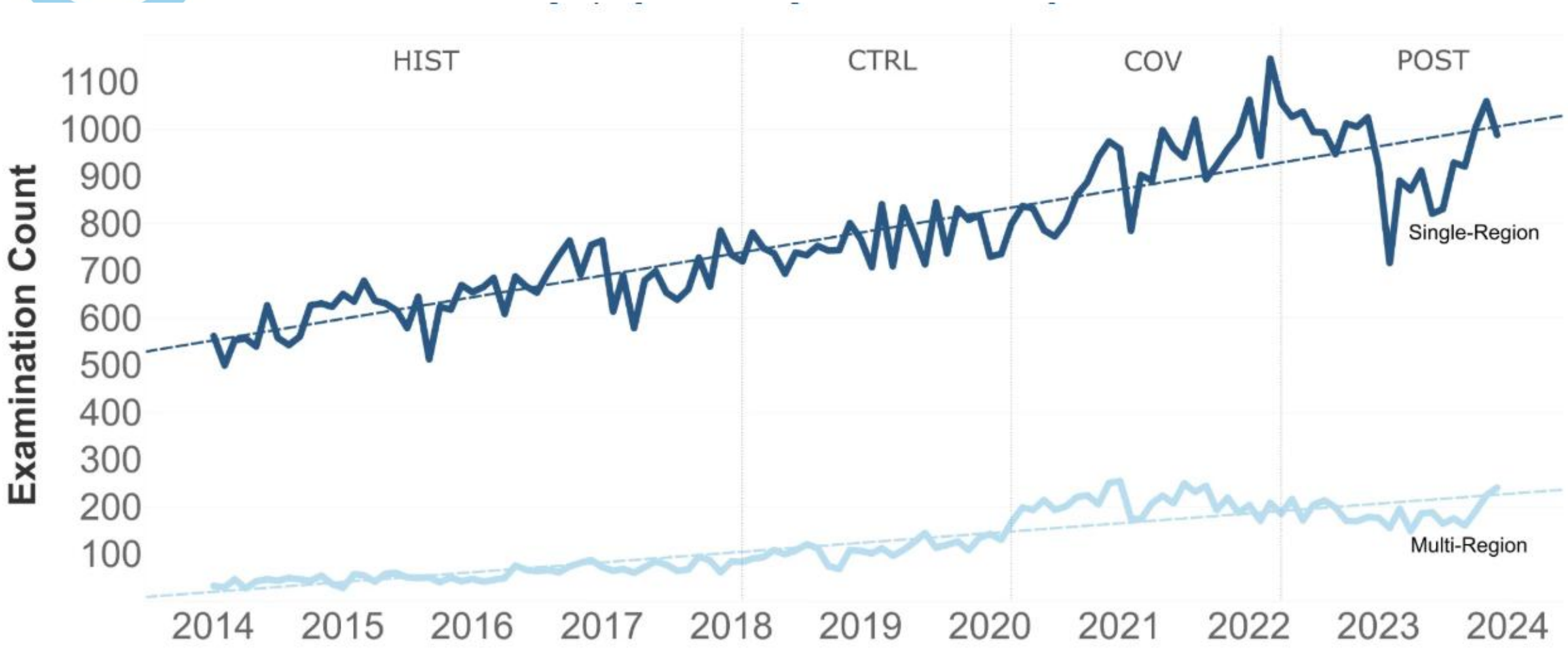
- *Diagnostická výtěžnost*
  - TRO 17,4 %
  - CCTA 18,3 %
- *Diagnostická výtěžnost u mužů*
  - TRO 25,2 %
  - CCTA 21,9 %
- *Diagnostická výtěžnost u žen*
  - TRO **11,5 %**
  - CCTA 14,5 %

Burris AC 2nd, Boura JA, Raff GL, Chinnaiyan KM. Triple Rule Out Versus Coronary CT Angiography in Patients With Acute Chest Pain: Results From the ACIC Consortium. JACC Cardiovasc Imaging. 2015 Jul;8(7):817-25. doi: 10.1016/j.jcmg.2015.02.023. Epub 2015 Jun 17. PMID: 26093928.

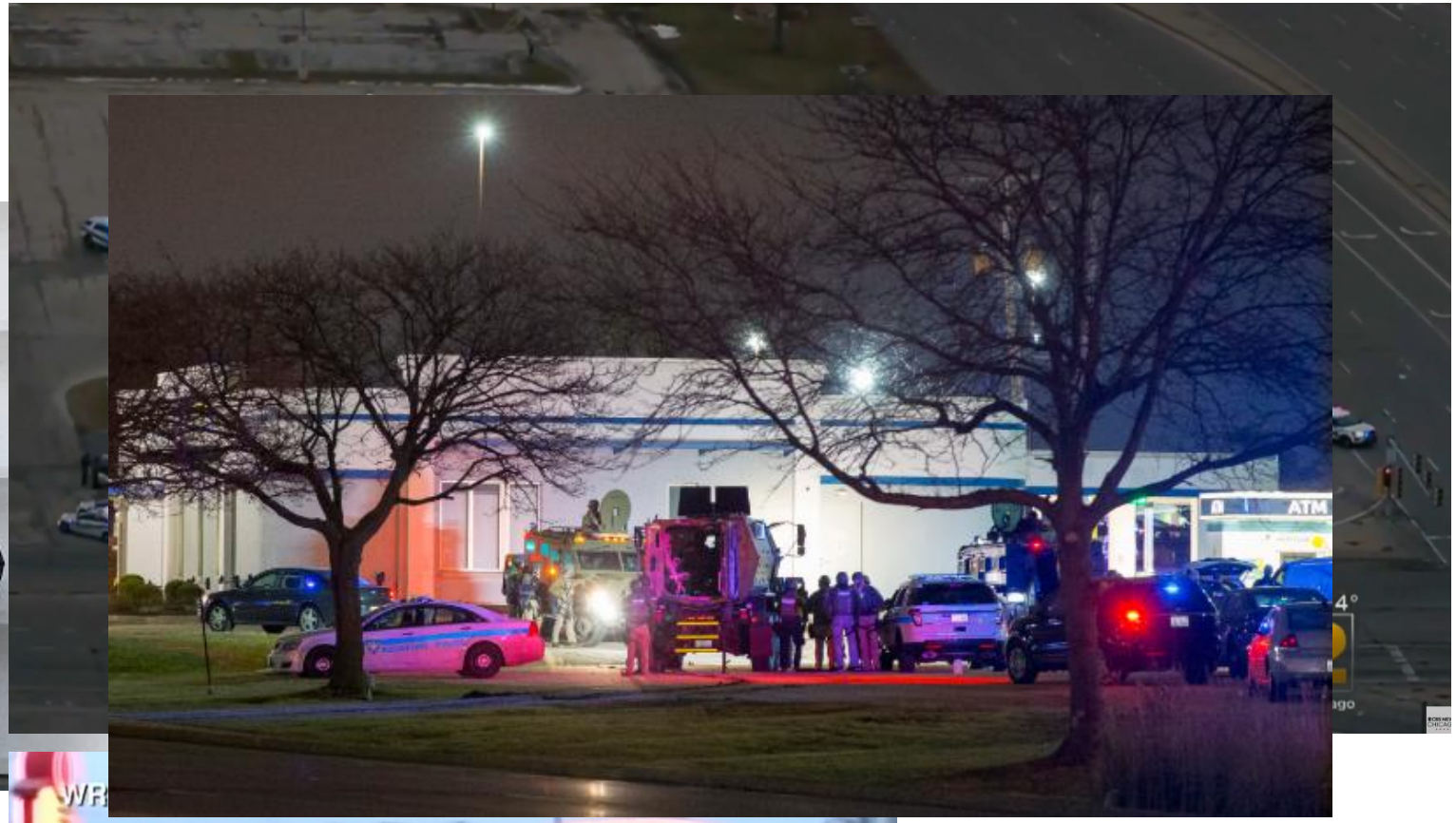
Indikace, kontr aindikace a reálná praxe

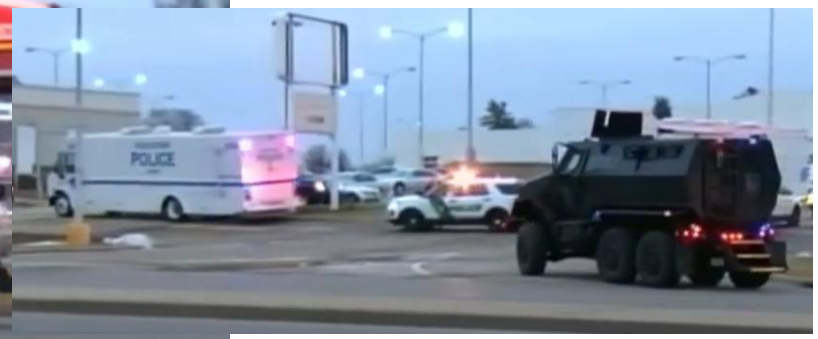
Triple Rule Out

- Kontraindikace
  - Vysoká pravděpodobnost AKS
  - Kontraindikace CT
- Indikace
  - Skórovací systémy
    - HEART, PERC, ADD-RS, …
    - ≥ 2 diagnózy
- Praxe
  - Protokol aorta+plicnice



Kempter F, Heye T, Vosshenrich J, Ceresa B, Jäschke D. Trends in CT examination utilization in the emergency department during and after the COVID-19 pandemic. BMC Med Imaging. 2024 Oct 21;24(1):283. doi: 10.1186/s12880-024-01457-4. PMID: 39433984; PMCID: PMC11492618.





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https://www.youtube.com/watch?v=AfPkHnbJfCE

Triple Rule Out CT

- Technicky proveditelné
- Problem solving metoda
- Kontroverze
  - Radiační zátěž
  - Radiologie
    - *Technické vybavení*
    - *personální zabezpečení & kvalita hodnocení*
  - Urgentní příjem
    - *nadměrené indikování*

Děkuji za pozornost