Pearls and Pitfalls of Abdominal Computerized Tomography

Mustafa Kesapli,MD
Training and Research Hospital
Antalya/Turkey

Objectives

- Epidemiology
- İndications of abdominal CT in ED
  - Life-threating conditions of abdominal pain
  - Trauma/penetran injury
- Advantages
  - Diagnostic efficiacy of abdominal CT
- Disadvantages
  - Radiation exposure
  - Contrast/non-contrast enhanced CT
  - İncidentaloma's
- Special groups (pregnancy,child,older)
- Future of abdominal CT
- Summary

Epidemiology

- Patient presenting with abdominal/pelvic pain will undergo CT as part of their evaluation was almost 10 times higher in 2007 compared with in 1996. At this period ,just 30% patient increased (1).
- It is estimated that the total number of CT examinations annually performed in the United States has increased from 3 million in 1980 to more than 100 million CT in 2016 (2).
- Most increased **abdominal CT (10 times)**, thorax CT 5 times(3)
- 25% of CT in emergency department (4)

1. Kocher KE et al. (2006) National trends in the use of computed tomography in the emergency department, 2000–2005. Emerg Radiol 13:25–30.

2. 2.World Health Organization communicating radiation risks in paediatric imaging (2016). http://www.who.int/ionizing_radiation/pub_meet/radiation-risks-paediatric-imaging/en.

3.Laack TA et al. Comparison of trauma mortality and estimated cancer mortality from computed tomography during initial evaluation of intermediate-risk trauma patients. J Trauma. 2011;70:1362–5.

4. Kocher KE et al. National trends in use of computed tomography in the emergency department. Ann Emerg Med. 2011;58:452-462.

Epidemiology

- 3.217.396 patients,a meta analysis
- Adult patients,emergency CT using 16.7%
- Children 5.3%
- 24,6% older than 65 years

- Kirsch et al. Computed Tomography Scan Utilization in Emergency Departments:A multi-State Analysis,The Journal of Emergency Medicine, Vol. 41, No. 3, pp. 302–309, 2011

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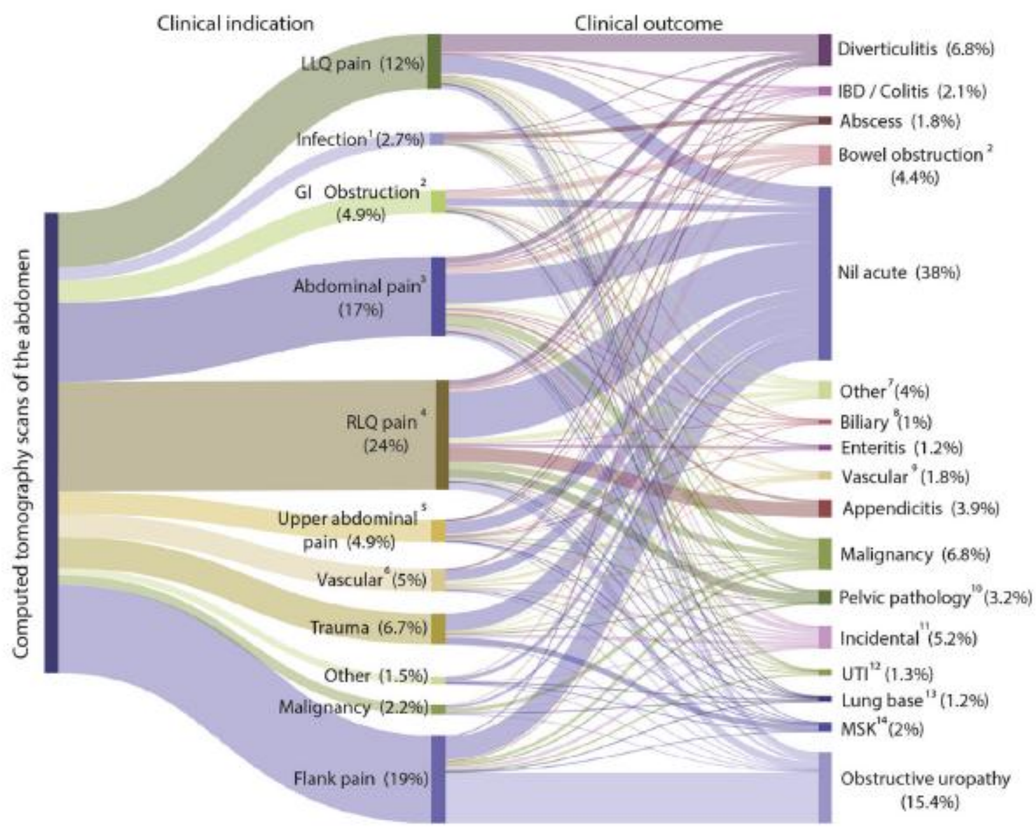
Trauma and Emergency Room Imaging / L'imagerie des urgences et des traumatismes

Retrospective Analysis of Emergency Computed Tomography Imaging Utilization at an Academic Centre: An Analysis of Clinical Indications and Outcomes

Jason Seidel, BSc, MD*, Mary Beth Bissell, MSc, MD, Sannihita Vatturi, Angus Hartery, MD, FRCPC

Department of Diagnostic Radiology, Memorial University, St John's, Newfoundland and Labrador, Canada



Increasing CT in ED

- Over the last 20 years, CT scanner availability has rapidly increased worldwide .
- CT is more accessible in the ED .(even resus room)
- Low availability of other imaging modalities, such as MRI,USG-CT is preferable by ED staff .
- Malpractice lawsuit in busy ED
- Defensive medical decision
- Procedural advantages
  - Non-dependent to personal
  - Abdominal gases,obesity not connect to the image quality
  - Retroperitoneal visualization
  - New technologies of CT machines
    - High image quality (especially helpful in children)
    - Multiplanar reconstruction(transvers,sagittal,coronal)
    - Multidedector machines

Indications of Abdominal CT in ED

Life-threatening reasons

- Abdominal aortic aneurysm
- Thoracoabdominal aortic dissection
- İntraabdominal hemorragia
- Penetran abdominal trauma
- Mesenteric ischemia
- Perforation of gastrointestinal tract (peptic ulcer, bowel, esophagus, or appendix)
- Acute bowel obstruction,volvulus
- Splenic rupture
- Incarcerated hernia
- Ectopic pregnancy

Others

- Appendicitis
- Renal stone
- Hernia
- Pancreatitis
- Biliary obstruction
- Malignancy
- İntraabdominal abcess
- Gynecological pathologies

ACR Appropriateness Criteria Acute Nonlocalized Abdominal Pain

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https://doi.org/j.jacr.2018.09.010

Variant 1. Acute nonlocalized abdominal pain and fever. No recent surgery. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	○
US abdomen	May Be Appropriate	○
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without IV contrast	May Be Appropriate	○
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography abdomen	May Be Appropriate	☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
In-111 WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Tc-99m cholescintigraphy	Usually Not Appropriate	☢☢
Tc-99m WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	☢☢☢

Variant 2. Acute nonlocalized abdominal pain and fever. Postoperative patient. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	○
US abdomen	May Be Appropriate	○
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without IV contrast	May Be Appropriate	○
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography abdomen	May Be Appropriate	☢☢
Fluoroscopy contrast enema	May Be Appropriate	☢☢☢
Fluoroscopy upper GI series with small bowel follow-through	May Be Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
In-111 WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Tc-99m cholescintigraphy	Usually Not Appropriate	☢☢
Tc-99m WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢

Table 2. Relative radiation level designations

RRL	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
○	0	0
☢	<0.1	<0.03
☢☢	0.1-1	0.03-0.3
☢☢☢	1-10	0.3-3
☢☢☢☢	10-30	3-10
☢☢☢☢☢	30-100	10-30

Note: Relative radiation level (RRL) assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “varies.”

ACR Appropriateness Criteria Acute Nonlocalized Abdominal Pain

Variant 3. Acute nonlocalized abdominal pain. Neutropenic patient. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	○
US abdomen	May Be Appropriate	○
MRI abdomen and pelvis without IV contrast	May Be Appropriate	○
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
In-111 WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Tc-99m WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Tc-99m cholescintigraphy	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	☢☢☢

Variant 4. Acute nonlocalized abdominal pain. Not otherwise specified. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Appropriate	○
US abdomen	May Be Appropriate	○
MRI abdomen and pelvis without IV contrast	May Be Appropriate	○
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography abdomen	May Be Appropriate	☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
In-111 WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Tc-99m cholescintigraphy	Usually Not Appropriate	☢☢
Tc-99m WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	☢☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢

Table 2. Relative radiation level designations

RRL	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
○	0	0
☢	<0.1	<0.03
☢☢	0.1-1	0.03-0.3
☢☢☢	1-10	0.3-3
☢☢☢☢	10-30	3-10
☢☢☢☢☢	30-100	10-30

Note: Relative radiation level (RRL) assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "varies."

Diagnostic efficiacy of abdominal CT

- In a prospective study, assessing impact of CT on management decisions in the ED, a total of 584 patients presented with nontraumatic abdominal complaints;
  - CT changed leading diagnosis in 49%
  - changed admission status in 24%
  - altered surgical plans in 25% .(1)
- A prospective trial,547 patients, presenting to the ED with abdominal pain demonstrated that CT altered the diagnosis in 54% of patients and frequently changed disposition patterns.(2)
- More recently, a multicenter prospective observational trial of 460 patients referred for AbdCT for AAP. Pre and post AbdCT diagnoses and admission plans were compared. AbdCT changed the provider's diagnosis in 51% of patients and the admission plan in 25%(3)

1.Abujudeh HH et al. Abdominopelvic CT increases diagnostic certainty and guides management decisions: a prospective investigation of 584 patients in a large academic medical center. AJR Am J Roentgenol 2011;196:238-43.

2.Barksdale AN et al.Diagnosis and disposition are changed when board-certified emergency physicians use CT for non-traumatic abdominal pain. Am J Emerg Med 2015;33:1646-50

3. Pandharipande P et al. CT in the emergency department:a real-time study of changes in physician decision making. Radiol. 2016;278:812e821.

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The utility of CT scan for the diagnostic evaluation of acute abdominal pain

Timothy Bax [a], Matthew Macha [b], John Mayberry [c, *]

Representative key studies on the utility of AbdCT for the evaluation of generalized acute abdominal pain.

Authors/Year	Study Type	CT Technique	Patients	% Scan	Changed plan/helpful	Country
Rosen et al. 2000[15]	Prospective	Helical Variety IV/oral contrast	57	100%	60%	US
Nagurney et al. 2001[16]	Prospective	Not specified	124	48%	43%	US
Modahl et al. 2006[17]	Retrospective	4-slice Variety IV/oral/rectal contrast	604	100%	38%	US
Lewis et al. 2007[18]	Prospective	Not specified	126	59%	46%	US
Lameris et al. 2009[22]	Prospective	3 mm slices IV contrast No enteral contrast	1101	100%	50%	Netherlands
Abujudeh et al. 2011[19]	Prospective	Not specified	584	100%	42%	US
Lehtimaki et al. 2012[28]	Prospective Randomized	64 row multidetector IV contrast No enteral contrast	254	74%	Not reported	Finland
Pandharipande et al. 2015[21]	Prospective	Not specified	460	100%	51%	US
Caporale et al. 2016[30]	Prospective	Not specified Variable contrast	239	16%	87%	Italy
Alshamari et al. 2016[31]	Prospective	Low-dose 5 mm slices No contrast	58	100%	Not reported	Sweden
Velissaris et al. 2017[32]	Prospective	Not specified	125	17%	Not reported	Greece

Trauma/penetran injury

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World Journal of Emergency Surgery

RESEARCH ARTICLE Open Access

Outcomes of selective nonoperative management of civilian abdominal gunshot wounds: a systematic review and meta-analysis

Aziza N. Al Rawahi[1†], Fatma A. Al Hinai[1], Jamie M. Boyd[2], Christopher J. Doig[2], Chad G. Ball[1,3], George C. Velmahos[4], Andrew W. Kirkpatrick[1,2,3], Pradeep H. Navsaria[5,6] and Derek J. Roberts[7*†]

Abstract

Background: Although mandatory laparotomy has been standard of care for patients with abdominal gunshot wounds (GSWs) for decades, this approach is associated with non-therapeutic operations, morbidity, and long hospital stays. This systematic review and meta-analysis sought to summarize outcomes of selective nonoperative management (SNOM) of civilian abdominal GSWs.

Methods: We searched electronic databases (March 1966–April 1, 2017) and reference lists of articles included in the systematic review for studies reporting outcomes of SNOM of civilian abdominal GSWs. We meta-analyzed the associated risks of SNOM-related failure (defined as laparotomy during hospital admission), mortality, and morbidity across included studies using DerSimonian and Laird random-effects models. Between-study heterogeneity was assessed by calculating I^2 statistics and conducting tests of homogeneity.

(Continued on next page)

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Results: Of 7155 citations identified, we included 41 studies [n = 22,847 patients with abdominal GSWs, of whom 6777 (29.7%) underwent SNOM]. The pooled risk of failure of SNOM in hemodynamically stable patients without a reduced level of consciousness or signs of peritonitis was 7.0% [95% confidence interval (CI) = 3.9–10.1%; I^2 = 92.6%, homogeneity $p < 0.001$] while the pooled mortality associated with use of SNOM in this patient population was 0.4% (95% CI = 0.2–0.6%; I^2 = 0%, homogeneity $p > 0.99$). In patients who failed SNOM, the pooled estimate of the risk of therapeutic laparotomy was 68.0% (95% CI = 58.3–77.7%; I^2 = 91.5%; homogeneity $p < 0.001$). Risks of failure of SNOM were lowest in studies that evaluated patients with right thoracoabdomen (3.4%; 95% CI = 0–7.0%; I^2 = 0%; homogeneity $p = 0.45$), flank (7.0%; 95% CI = 3.9–10.1%), and back (3.1%; 95% CI = 0–6.5%) GSWs and highest in those that evaluated patients with anterior abdomen (13.2%; 95% CI = 6.3–20.1%) GSWs. In patients who underwent mandatory abdominopelvic computed tomography (CT), the pooled risk of failure was 4.1% versus 8.3% in those who underwent selective CT ($p = 0.08$). The overall sample-size-weighted mean hospital length of stay among patients who underwent SNOM was 6 days versus 10 days if they failed SNOM or developed an in-hospital complication.

Conclusions: SNOM of abdominal GSWs is safe when conducted in hemodynamically stable patients without a reduced level of consciousness or signs of peritonitis. Failure of SNOM may be lower in patients with GSWs to the back, flank, or right thoracoabdomen and be decreased by mandatory use of abdominopelvic CT scans.

Keywords: Abdominal gunshot wounds, Selective nonoperative management, Penetrating trauma, Wounds and injuries

Trauma/penetran injury

Current Pediatric Reviews, 2018, *14*, 59-63

REVIEW ARTICLE

BENTHAM SCIENCE

Pediatric Abdominal Trauma

Tim Lynch[1,*], Jennifer Kilgar[1] and Amal Al Shibli[2]

[1]*Department of Pediatrics and Medicine, Schulich School of Medicine, Western University, London, Ontario, Canada;* [2]*Department of Pediatric Emergency, Children's Hospital, London Health Sciences Center, London, Ontario, Canada*

Abstract: Abdominal trauma is present in approximately 25% of pediatric patients with major trauma and is the most common cause of unrecognized fatal injury in children. Pediatric abdominal trauma is typically blunt in nature with the spleen being the most common organ injured. Non-operative management is employed in over 95% of patients.

Penetrating injuries are less common but often require operative management. Knowledge of specific mechanisms of injury aids the clinician in the diagnosis of specific injuries.

Computed Tomography (CT) is the gold standard in the identification of intra-abdominal injury. Focused Assessment with Sonography for Trauma (FAST) can detect the presence of free fluid suggestive of intra-abdominal injury. In children, the utility of FAST is limited because less than half of pediatric patients with abdominal injury have free fluid. Bowel perforation and pancreatic injuries may not be evident on initial CT scanning of the abdomen.

Initial management of the trauma patient in shock includes fluid boluses of normal saline or Ringer's lactate with two, large-bore upper extremity catheters. Transfusion with packed red blood cells is done if the patient remains hypotensive after the second fluid bolus. Emergent laparotomy is indicated in patients with: free intraperitoneal air, hemodynamic instability despite maximal resuscitative efforts (transfusion of greater than 50% of total blood volume), gunshot wound to the abdomen or other penetrating traumas, and evisceration of intraperitoneal contents.

Initial FAST followed by abdominal computed tomography is important in the evaluation of the seriously or critically injured patient. The combination of the FAST exam along with selected abdominal computed tomography can further aid in the detection of injuries that may not be clinically apparent.

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ORIGINAL ARTICLE

CT-guided tractography is a safe and complementary diagnostic tool in the management of penetrating abdominal trauma

Muzaffer Akkoca [a,*], Sener Balas [a], Kerim Bora Yilmaz [a], Idil Gunes Tatar [b], Melih Akinci [a], Serhat Tokgoz [a], Selim Tamam [a], Harun Karabacak [a]

[a] *University of Health Sciences, Dışkapı Yıldırım Beyazıt Research and Training Hospital, Department of General Surgery, Ankara, Turkey*

[b] *University of Health Sciences, Dışkapı Yıldırım Beyazıt Research and Training Hospital, Department of Radiology, Ankara, Turkey*

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KEYWORDS

Computed tomography guided tractography;

Penetrating abdominal trauma;

Therapeutic trauma laparotomy;

Negative laparotomy

Summary *Background/Objective:* Despite extensive published research, the surgical approach to penetrating abdominal trauma patients is still under debate. Computed tomography-guided tractography (CTT) is an imaging modality in which water soluble iodinated contrast medium is administered into the site of the injury in the CT unit. The aim of this study was to determine the diagnostic accuracy of the CTT.

Methods: A retrospective evaluation was made of patients admitted to the Emergency Department with penetrating abdominal trauma and who underwent CTT. Contrast enhanced abdominal CT and CTT reports, surgical findings and clinical results were examined.

Results: Evaluation was made of a total of 101 patients comprising 89 males (88.1%) and 12 females (11.9%). CTT was determined to have 92.8% sensitivity, 93.6% specificity, 97% positive predictive value, and 85.5% negative predictive value. In 27 patients (26.7%) where the CTT indicated passage through the peritoneum, no parenchymal organ injury was present. Only one patient (2.9%) without peritoneal penetration on CTT had organ injury at exploration. No procedure-related morbidities developed.

Conclusion: CTT is a safe imaging modality for the evaluation of hemodynamically stable patients. Compared to other imaging modalities, there is clearer demonstration of whether or not the peritoneum is intact. However penetration on CTT does not exactly correlate with organ injury.

* Corresponding author. University of Health Sciences, Dışkapı Research and Training Hospital, Department of General Surgery, Altındağ/Ankara, 06110, Turkey. Fax: +90 312 596 20 00.

E-mail address: muzafferakk@gmail.com (M. Akkoca).

Abdominal CT

- It provides more accurate diagnosis
- Cost effective
- Non-personel dependent
- Fast
- Gold standart mostly

Radiation exposure of CT?

Table 1
Effective Radiation Dose by Radiologic Study [51,52].

Examination	Average effective dose (mSv)
WBCT	24
Brain	1.8
CTA brain	2.5
Sinuses	0.6
Cervical spine	3
CTA carotids	4.4
Chest	5.1
CTA chest	2.4
Thoracic spine	12
Abdomen	11
Kidney	11
Lumbar spine	12
Pelvis (dedicated)	4.5

Whole body computed tomography versus selective radiological imaging strategy in trauma: An evidence-based clinical review. Long B et al. Am J Emerg Med.2017 March 21.

Lifetime attributable risk for cancer

- US population, age dependent risks combine to produce an average lifetime attributable risk(LAR) of one radiation-induced cancer per 100,000 patients receiving a 100-mSv effective dose.(1)
- A study by Pearce et al. demonstrated 2-3 fold increase in incidence of leukemia and brain tumors in people who were exposed to radiation during their childhood (2).
- 1945 atomic bomb survivors in Japan who experienced a mean effective dose of 40 mSv. These survivors are known to have an increased cancer risk,and a similar exposure can be reached in five to six CT scan.(3)

1.Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. http://www.nap.edu/catalog/11340/ health-risks-from-exposure-to-low-levels-of-ionizing-radiation (2006).

2.Pearce MS et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: A retrospective cohort study. The Lancet. 2012;380(9840):499—505

3. Rohner D et al.Cumulative total effective while-body radiation dose in critically ill patients.Chest.2013;144(5):1481-1486

Eur J Trauma Emerg Surg (2018) 44:19–27
https://doi.org/10.1007/s00068-016-0665-6

CrossMark

ORIGINAL ARTICLE

Cumulative radiation exposure and estimated lifetime cancer risk in multiple-injury adult patients undergoing repeated or multiple CTs

S. Kritsaneepaiboon[1] · A. Jutiyon[1] · A. Krisanachinda[2]

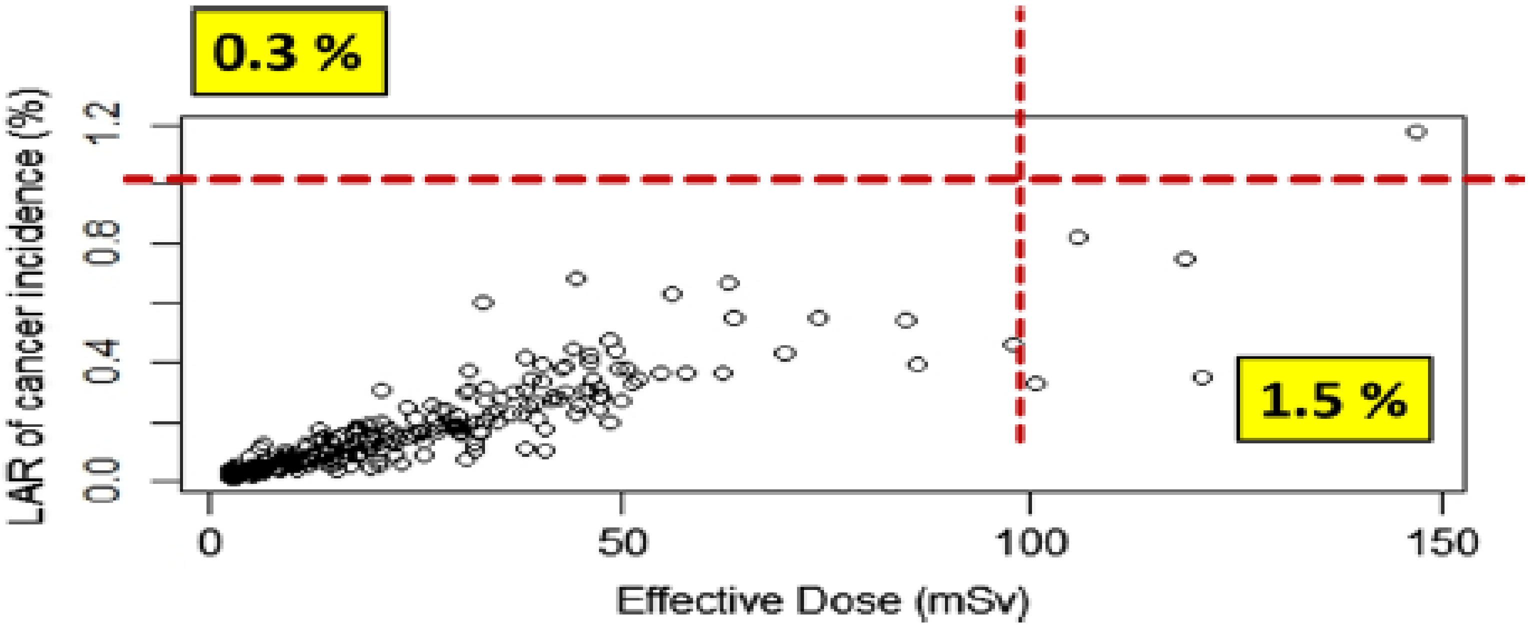

Fig. 4 High risk of radiation-induced cancer in effective dose >100 mSv and LAR >1 %

Reduced-dose CT

Original Article

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SAGE

Evaluation of reduced-dose CT for acute non-traumatic abdominal pain: evaluation of diagnostic accuracy in comparison to standard-dose CT

Ahmed E Othman[1], Malte Niklas Bongers[1], Dominik Zinsser[1], Christoph Schabel[1], Julian L Wichmann[2], Rami Arshid[3], Mike Notohamiprodjo[1], Konstantin Nikolaou[1] and Fabian Bamberg[1]

Abstract

Background: Patients with acute non-traumatic abdominal pain often undergo abdominal computed tomography (CT). However, abdominal CT is associated with high radiation exposure.

Purpose: To evaluate diagnostic performance of a reduced-dose 100 kVp CT protocol with advanced modeled iterative reconstruction as compared to a linearly blended 120 kVp protocol for assessment of acute, non-traumatic abdominal pain.

Material and Methods: Two radiologists assessed 100 kVp and linearly blended 120 kVp series of 112 consecutive patients with acute non-traumatic pain (onset <48 h) regarding image quality, noise, and artifacts on a five-point Likert scale. Both radiologists assessed both series for abdominal pathologies and for diagnostic confidence. Both 100 kVp and linearly blended 120 kVp series were quantitatively evaluated regarding radiation dose and image noise. Comparative statistics and diagnostic accuracy was calculated using receiver operating curve (ROC) statistics, with final clinical diagnosis/clinical follow-up as reference standard.

Results: Image quality was high for both series without detectable significant differences ($P=0.157$). Image noise and artifacts were rated low for both series but significantly higher for 100 kVp ($P\leq 0.021$). Diagnostic accuracy was high for both series (120 kVp: area under the curve [AUC] = 0.950, sensitivity = 0.958, specificity = 0.941; 100 kVp: AUC ≥ 0.910, sensitivity ≥ 0.937, specificity = 0.882; $P\geq 0.516$) with almost perfect inter-rater agreement (Kappa = 0.939). Diagnostic confidence was high for both dose levels without significant differences (100 kVp 5, range 4–5; 120 kVp 5, range 3–5; $P=0.134$). The 100 kVp series yielded 26.1% lower radiation dose compared with the 120 kVp series (5.72 ± 2.23 mSv versus 7.75 ± 3.02 mSv, $P<0.001$). Image noise was significantly higher in reduced-dose CT (13.3 ± 2.4 HU versus 10.6 ± 2.1 HU; $P<0.001$).

Conclusion: Reduced-dose abdominal CT using 100 kVp yields excellent image quality and high diagnostic accuracy for the assessment of acute non-traumatic abdominal pain.

- Advanced iterative image reconstruction algorithms increase image quality.
- Standard-dose 120 kVp to reduced 100kVp CT protocol series.
- Radiation dose 5.7mSV

Reduced-dose CT

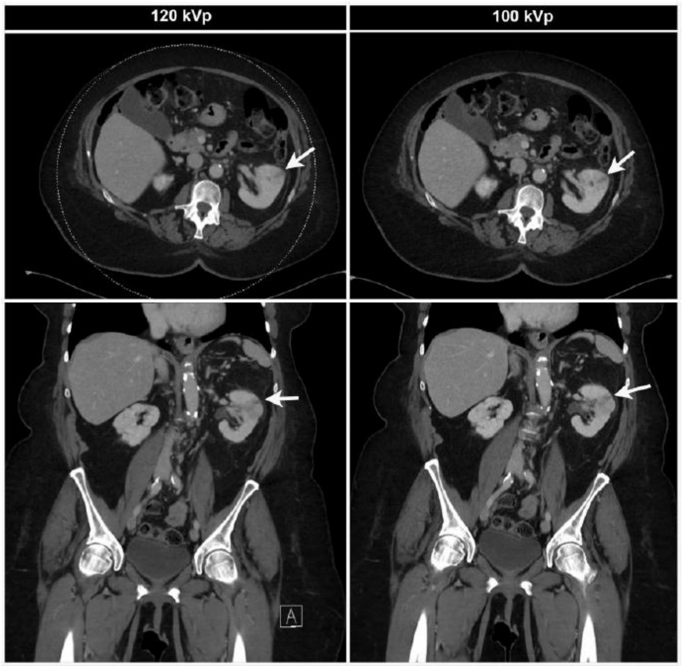

Fig. 3. Standard-dose and reduced-dose images of a 75-year-old obese female patient with acute left-sided abdominopelvic
Patient was diagnosed with acute pyelonephritis. Note the comparable image quality of both 100 kVp and linearly blended series.

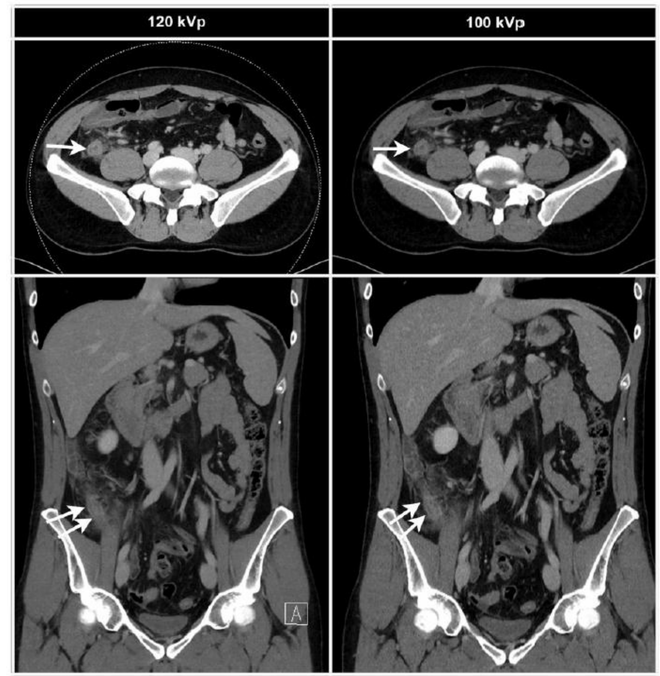

Fig. 4. Linearly blended 120 kVp and 100 kVp series of a 34-year-old male patient with acute right lower abdominal pain. Patient w
diagnosed with acute appendicitis.

Table 2. Diagnostic accuracy, sensitivity and specificity with corresponding 95% CIs for both dose levels (i.e. both series) and both readers.

	AUC (95% CI)		Sensitivity (95% CI)		Specificity (95% CI)	
CT protocol	Reader A	Reader B	Reader A	Reader B	Reader A	Reader B
120 kVp series	0.950 (0.881–1.00)	0.950 (0.881–1.00)	0.958 (0.890–0.986)	0.958 (0.890–0.986)	0.941 (0.692–0.996)	0.941 (0.692–0.996)
100 kVp series	0.910 (0.816–1.00)	0.920 (0.828–1.00)	0.937 (0.862–0.974)	0.958 (0.890–0.986)	0.882 (0.623–0.979)	0.882 (0.623–0.979)

Reduced-dose CT

80-kVp scan

ARTICLE IN PRESS

RADIATION SENSIBILITIES

RICHARD L. MORIN, PhD, DONALD P. FRUSH, MD

Abdominal CT Imaging Applications of Low Kilovoltage Peak Techniques

Michael I. Levinson, DO, Matthew Hoerner, PhD, Adel Mustafa, PhD, Jay K. Pahade, MD

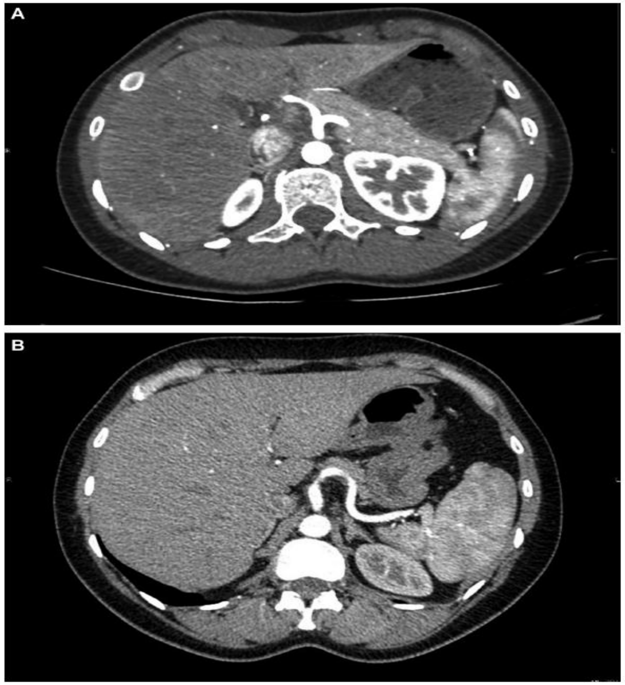

Fig 1. (A) Radiation dose of liver donor CT angiography (CTA) at 80 kilovoltage peak (kVp). (B) Radiation dose of a liver donor CTA at 120 kVp. Representative images from both CTAs show similar image quality in these similar-size patients but substantial reduction in total examination Dose-Length Product (DLP) using low-kVp technique and slightly shorter z axis coverage.

Abdominal CT İmaging Applications of Low Kilovoltage Peak Techniques

Michael L Levinston et al, Journal of American College of Radiology,2018,DOI:Jacr2018.09.053

BJR

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FULL PAPER

Application of 80-kVp scan and raw data-based iterative reconstruction for reduced iodine load abdominal–pelvic CT in patients at risk of contrast-induced nephropathy referred for oncological assessment: effects on radiation dose, image quality and renal function

[1,2]YASUNORI NAGAYAMA, MD, [1,2]SHOTA TANOUE, MD, [1]AKINORI TSUJI, MD, [1]JOJI URATA, MD, [1]MITSUHIRO FURUSAWA, MD, [2]SEITARO ODA, MD, [2]TAKESHI NAKAURA, MD, [2]DAISUKE UTSUNOMIYA, MD, [1,2]ERI YOSHIDA, MD, [2]MORIKATSU YOSHIDA, MD, [2]MASAFUMI KIDOH, MD, [1,2]MACHIKO TATEISHI, MD and [2]YASUYUKI YAMASHITA, MD

[1]Department of Radiology, Kumamoto City Hospital, Kumamoto, Japan
[2]Department of Diagnostic Radiology, Graduate School of Medical Sciences, Kumamoto University, Kumamoto, Japan

Address correspondence to: Dr Yasunori Nagayama
E-mail: *y.nagayama1980@gmail.com*

Objective: To evaluate the image quality, radiation dose, and renal safety of contrast medium (CM)-reduced abdominal-pelvic CT combining 80-kVp and sinogram-affirmed iterative reconstruction (SAFIRE) in patients with renal dysfunction for oncological assessment.
Methods: We included 45 patients with renal dysfunction (estimated glomerular filtration rate <45 ml per min per 1.73 m^2) who underwent reduced-CM abdominal–pelvic CT (360 mgI kg^{-1}, 80-kVp, SAFIRE) for oncological assessment. Another 45 patients without renal dysfunction (estimated glomerular filtration rate >60 ml per lmin per 1.73 m^2) who underwent standard oncological abdominal–pelvic CT (600 mgI kg^{-1}, 120-kVp, filtered-back projection) were included as controls. CT attenuation, image noise, and contrast-to-noise ratio (CNR) were compared. Two observers performed subjective image analysis on a 4-point scale. Size-specific dose estimate and renal function 1–3 months after CT were measured.
Results: The size-specific dose estimate and iodine load of 80-kVp protocol were 32 and 41%,, respectively, lower than of 120-kVp protocol ($p < 0.01$). CT attenuation and contrast-to-noise ratio of parenchymal organs and vessels in 80-kVp images were significantly better than those of 120-kVp images ($p < 0.05$). There were no significant differences in quantitative or qualitative image noise or subjective overall quality ($p > 0.05$). No significant kidney injury associated with CM administration was observed.
Conclusion: 80-kVp abdominal–pelvic CT with SAFIRE yields diagnostic image quality in oncology patients with renal dysfunction under substantially reduced iodine and radiation dose without renal safety concerns.
Advances in knowledge: Using 80-kVp and SAFIRE allows for 40% iodine load and 32% radiation dose reduction for abdominal–pelvic CT without compromising image quality and renal function in oncology patients at risk of contrast-induced nephropathy.

Reduced-dose CT,appendicitis

European Radiology
https://doi.org/10.1007/s00330-017-5231-z

GASTROINTESTINAL

CrossMark

The diagnostic performance of reduced-dose CT for suspected appendicitis in paediatric and adult patients: A systematic review and diagnostic meta-analysis

Hee Mang Yoon[1] · Chong Hyun Suh[2] · Young Ah Cho[1] · Jeong Rye Kim[1] · Jin Seong Lee[1] · Ah Young Jung[1] · Jung Heon Kim[3] · Jeong-Yong Lee[4] · So Yeon Kim[1]

Received: 7 March 2017 / Revised: 5 November 2017 / Accepted: 1 December 2017

Abstract

Objective To evaluate the diagnostic performance of reduced-dose CT for suspected appendicitis.

Methods A systematic search of the MEDLINE and EMBASE databases was carried out through to 10 January 2017. Studies evaluating the diagnostic performance of reduced-dose CT for suspected appendicitis in paediatric and adult patients were selected. Pooled summary estimates of sensitivity and specificity were calculated using hierarchical logistic regression modelling. Meta-regression was performed.

Results Fourteen original articles with a total of 3,262 patients were included. For all studies using reduced-dose CT, the summary sensitivity was 96 % (95 % CI 93–98) with a summary specificity of 94 % (95 % CI 92–95). For the 11 studies providing a head-to-head comparison between reduced-dose CT and standard-dose CT, reduced-dose CT demonstrated a comparable summary sensitivity of 96 % (95 % CI 91–98) and specificity of 94 % (95 % CI 93–96) without any significant differences (p=.41). In meta-regression, there were no significant factors affecting the heterogeneity. The median effective radiation dose of the reduced-dose CT was 1.8 mSv (1.46–4.16 mSv), which was a 78 % reduction in effective radiation dose compared to the standard-dose CT.

Conclusion Reduced-dose CT shows excellent diagnostic performance for suspected appendicitis.

Table 4 Head-to-head comparison of effective radiation dose between reduced-dose CT and standard-dose CT in adult patients

	Effective radiation dose (mSv)	
First author (year of publication)	Reduced-dose CT	Standard-dose CT
Chang et al. (2016) [18]	4.16	9.8
Keyzer et al. (2004) [23]	1.73	5.94
Kim et al. (2012) [24]	1.74	7.82
Kim et al. (2011) [25]	1.83	8.16
Platon et al. (2009) [27]	1.46	8.77
Seo et al. (2009) [29]	4.2	8.0
Yun et al. (2016) [30]	1.8	7.0
Median	1.8	8.0

- Reduced-dose CT shows excellent diagnostic performance for suspected appendicitis with pooled sensitivity of 96 % and specificity of 94 %.
- The median effective radiation dose of reduced dose CT was 1.8 mSv.

Methods to reduce radiation exposure

- **ALARA** (As Low As Reasonably Achievable) principle;
- ALARA is an acronym used in radiation safety for “As Low As Reasonably Achievable’’
- The ALARA radiation safety principle is based on the minimization of radiation doses and limiting the release of radioactive materials into the environment by employing all “reasonable methods.
- ALARA is not only a sound radiation safety principle, but it is a regulatory requirement for all “radiation protection programs
  - resulted in a reduction of 62.7% in the rate of abdominal CT phases per visit during the study period,
  - concurrently with a rise in the number abdominal US scans ordered by the ED

- Sodhi KS et al. Clinical application of 'Justification' and 'Optimization' principle of ALARA in pediatric CT imaging: How many children can be protected from unnecessary radiation? European Journal of Radiology. 2015.

Radiation and Environmental Biophysics (2018) 57:5–15
https://doi.org/10.1007/s00411-017-0726-1

REVIEW

Multidisciplinary European Low Dose Initiative (MELODI): strategic research agenda for low dose radiation risk research

M. Kreuzer[1] · A. Auvinen[2,3] · E. Cardis[4] · M. Durante[5] · M. Harms-Ringdahl[6] · J. R. Jourdain[7] · B. G. Madas[8] · A. Ottolenghi[9] · S. Pazzaglia[10] · K. M. Prise[11] · R. Quintens[12] · L. Sabatier[13] · S. Bouffler[14]

Received: 3 October 2017 / Accepted: 10 December 2017 / Published online: 15 December 2017

Abstract
MELODI (Multidisciplinary European Low Dose Initiative) is a European radiation protection research platform with focus on research on health risks after exposure to low-dose ionising radiation. It was founded in 2010 and currently includes 44 members from 18 countries. A major activity of MELODI is the continuous development of a long-term European Strategic Research Agenda (SRA) on low-dose risk for radiation protection. The SRA is intended to identify priorities for national and European radiation protection research programs as a basis for the preparation of competitive calls at the European level. Among those key priorities is the improvement of health risk estimates for exposures close to the dose limits for workers and to reference levels for the population in emergency situations. Another activity of MELODI is to ensure the availability of European key infrastructures for research activities, and the long-term maintenance of competences in radiation research via an integrated European approach for training and education. The MELODI SRA identifies three key research topics in low dose or low dose-rate radiation risk research: (1) dose and dose rate dependence of cancer risk, (2) radiation-induced non-cancer effects and (3) individual radiation sensitivity. The research required to improve the evidence base for each of the three key topics relates to three research lines: (1) research to improve understanding of the mechanisms contributing to radiogenic diseases, (2) epidemiological research to improve health risk evaluation of radiation exposure and (3) research to address the effects and risks associated with internal exposures, differing radiation qualities and inhomogeneous exposures. The full SRA and associated documents can be downloaded from the MELODI website (http://www.melodi-online.eu/sra.html).

Keywords Low-dose · Health effects · Cancer · Non-cancer · Individual sensitivity · Ionizing radiation

Contrast/non-contrast enhanced CT

- Intravenous (i.v.) contrast is helpful for diagnosing;
  - vascular abnormalities
  - İnfarctions
  - Abscesses
  - inflammatory disorders
  - distinguishing bile ducts
  - enhancing solid viscera
- İodinated i.v. contrast material is the third leading cause of acute kidney injury in the hospitalized patient.
  - mild to heavy allergic reactions
  - nephrotoxicity to death.

- Kagan A et al. Contrast-induced kidney injury: focus on modifiable risk factors and prophylactic strategies. Clin Cardiol 2010;33:62–6.

Orally contrast in ED

- Oral contrast is used to opacify the lumen of the gastrointestinal tract.
- Tolerance in the nauseated or vomiting patient and the time required to opacify the entire bowel have always been obstacles of oral contrast.
- Transit time through the gastrointestinal tract can take several hours, thereby increasing patient time spent in the ED.
- The time interval between arrival to the ED and disposition can be increased up to 3 h .(1)
- Who underwent abdominal and pelvic CT for various causes of acute abdominal symptoms in the emergency department, the elimination of oral contrast did not lead to any misdiagnosis.(2)

1.Huynh LN et al. Patient encounter time intervals in the evaluation of Emergency Department patients requiring abdominopelvic CT: oral contrast versus no contrast. Emerg Radiol 2004;10:310–3.

2. Alabousi A et al. Is oral contrast necessary for multidetector computed tomography imaging of patients with acute abdominal pain? CARJ 66(4):318–322,2015

Oral contrast necessary in ED?

CrossMark

Original Investigation

CT for Acute Nontraumatic Abdominal Pain—Is Oral Contrast Really Required?

Rivka Kessner, MD, Sophie Barnes, MD, Pinchas Halpern, MD, Vadim Makrin, MD, Arye Blachar, MD

Rationale and Objectives: This study aims to compare the diagnostic performance of abdominal computed tomography (CT) performed with and without oral contrast in patients presenting to the emergency department (ED) with acute nontraumatic abdominal pain.

Materials and Methods: Between December 2013 and December 2014, 348 adult patients presenting to the ED of a large tertiary medical center with nontraumatic abdominal pain were evaluated. Exclusion criteria for the study were history of inflammatory bowel disease, recent abdominal operation and suspected renal colic, abdominal aortic aneurysm rupture, or intestinal obstruction. All patients underwent intravenous contrast-enhanced abdominal CT on a Philips Brilliance 64-slice scanner using a routine abdomen protocol. The study group included 174 patients who underwent abdominal CT scanning without oral contrast, recruited using convenience sampling. A control group of 174 patients was matched to the cohort groups' gender and age and underwent abdominal CT with oral contrast material during the same time period. The patients' medical records were reviewed for various clinical findings and for the final clinical diagnosis. The CT exams were initially reviewed by a senior attending radiologist to determine the exams' technical adequacy and to decide whether an additional scan with oral contrast was required. Two senior radiologists, blinded to the clinical diagnosis, later performed consensus reading to determine the contribution of oral contrast administration to the radiologists' diagnostic confidence and its influence on diagnosing various radiological findings.

Results: Each group consisted of 82 men and 92 women. The average age of the two groups was 48 years. The main clinical diagnoses of the pathological examinations were appendicitis (17.5%), diverticulitis (10.9%), and colitis (5.2%). A normal CT examination was found in 34.8% of the patients. There was no significant difference between the groups regarding most of the clinical parameters that were examined. None of the examinations of all of the 174 study group patients was found to be technically inadequate, and therefore no patient had to undergo additional scanning to establish a diagnosis. The consensus reading of the senior radiologists determined that the lack of oral contrast was insignificant in 96.6% of the cases and that contrast material might have been useful in only 6 of 174 study group patients (3.4%). The radiologists found oral contrast to be helpful only in 8 of 174 control group patients (4.6%). There was no significant difference between the clinical and radiological diagnoses in both groups (study group, $P = 0.261$; control group, $P = 0.075$).

Conclusions: Our study shows that oral contrast is noncontributory to radiological diagnosis in most patients presenting to the ED with acute nontraumatic abdominal pain. These patients can therefore undergo abdominal CT scanning without oral contrast, with no effect on radiological diagnostic performance.

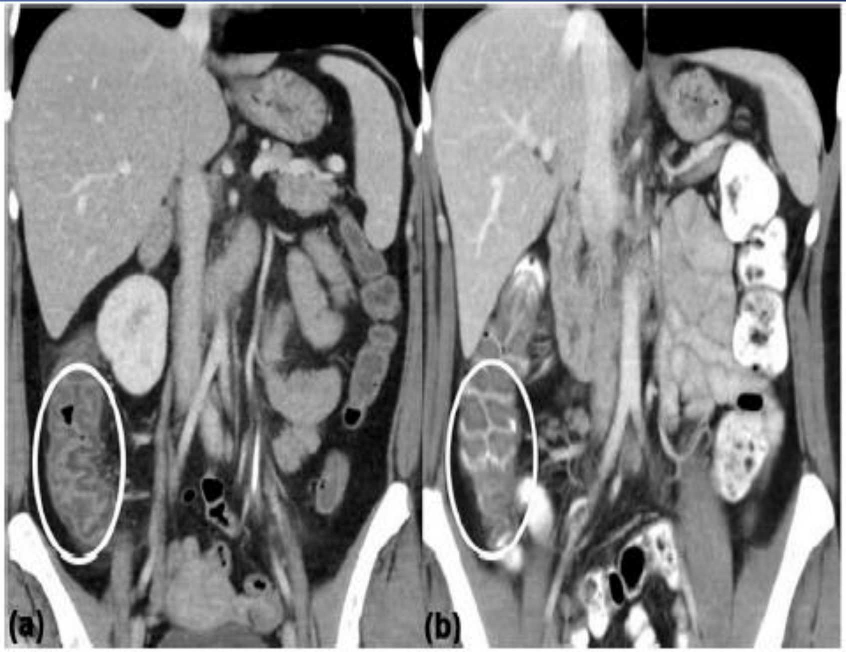


Figure 4. Two cases of colitis showing similar findings: **(a)** study group, **(b)** control group. The *circles* show inflammatory signs around the cecum in both patients.

Acad Radiol 2017; 24:840–845

Emerg Radiol
DOI 10.1007/s10140-016-1403-4

REVIEW ARTICLE

Oral contrast for CT in patients with acute non-traumatic abdominal and pelvic pain: what should be its current role?

Ania Z. Kielar[1] · Michael N. Patlas[2,3] · Douglas S. Katz[4]

Table 1 Compilation of published studies comparing final abdominal CT diagnoses between patients in the Emergency Department who did not receive oral contrast versus those who did

Author	Year of publication	Indication	Number of patients	Number of changes in final diagnosis after oral contrast
Hopkins CL	2012	Appendicitis, diverticulitis, SBO*, perforation	395	0
Levenson R	2012	Abdominal symptoms (not specified)	1218	0
Razavi SA	2014	Abdominal pain	2668	1
Alabousi A	2015	Abdominal pain	375	0

**SBO* small-bowel obstruction

Author	Year of publication	Number of patients	Median reduction in length of stay when no oral contrast used (compared to use of oral contrast) (min)
Huynh LH	2004	123	241
Schuur JD	2010	1806	30
Hopkins CL	2012	395	124
Kepner AM	2012	227	91
Razavi SA	2014	2668	43

Nephrotoxicity due to contrast agent

- According to the American College of Radiology(ACR) guidelines, CT of the abdomen and pelvis after intravenous contrast administration is the radiologic procedure with the highest diagnostic performance rating.
- Nephrotoxicity from i.v. contrast ranges;
  - 0% to 10% of people with normal renal function
  - 12% to 27% in those with preexisting renal impairment.

- Kagan A et al. Contrast-induced kidney injury: focus on modifiable risk factors and prophylactic strategies. Clin Cardiol 2010;33:62–6.

Acute Kidney Injury After Computed Tomography: A Meta-analysis

CrossMark

Ryan D. Aycock, MD, MS*; Lauren M. Westafer, DO, MPH; Jennifer L. Boxen, MLS, MA; Nima Majlesi, DO; Elizabeth M. Schoenfeld, MD, MS; Raveendhara R. Bannuru, MD, PhD

*Corresponding Author. E-mail: ryanaycock@gmail.com.

Study objective: Computed tomography (CT) is an important imaging modality used in the diagnosis of a variety of disorders. Imaging quality may be improved if intravenous contrast is added, but there is a concern for potential renal injury. Our goal is to perform a meta-analysis to compare the risk of acute kidney injury, need for renal replacement, and total mortality after contrast-enhanced CT versus noncontrast CT.

Methods: We searched MEDLINE (PubMed), the Cochrane Library, CINAHL, Web of Science, ProQuest, and Academic Search Premier for relevant articles. Included articles specifically compared rates of renal insufficiency, need for renal replacement therapy, or mortality in patients who received intravenous contrast versus those who received no contrast.

Results: The database search returned 14,691 articles, inclusive of duplicates. Twenty-six unique articles met our inclusion criteria, with an additional 2 articles found through hand searching. In total, 28 studies involving 107,335 participants were included in the final analysis, all of which were observational. Meta-analysis demonstrated that, compared with noncontrast CT, contrast-enhanced CT was not significantly associated with either acute kidney injury (odds ratio [OR] 0.94; 95% confidence interval [CI] 0.83 to 1.07), need for renal replacement therapy (OR 0.83; 95% CI 0.59 to 1.16), or all-cause mortality (OR 1.0; 95% CI 0.73 to 1.36).

Conclusion: We found no significant differences in our principal study outcomes between patients receiving contrast-enhanced CT versus those receiving noncontrast CT. Given similar frequencies of acute kidney injury in patients receiving noncontrast CT, other patient- and illness-level factors, rather than the use of contrast material, likely contribute to the development of acute kidney injury. [Ann Emerg Med. 2018;71:44-53.]

İncidentaloma’s

- Incidental finding’s
- Beyond radiation concerns with CT are the risks of false positive results or ‘incidentalomas.’
- The subsequent cascade testing can lead to increased morbidity, anxiety, and downstream costs and complications after that initial CT .
- VOMIT (Victims of Modern Imaging Technology)

Abdominal Imaging

Abdom Imaging (2015)
DOI: 10.1007/s00261-015-0349-4

Incidental findings detected on emergency abdominal CT scans: a 1-year review

M. E. Kelly,[1] A. Heeney,[1] C. E. Redmond,[2] J. Costelloe,[1] G. J. Nason,[1] J. Ryan,[3] D. Brophy,[2] D. C. Winter[3]

[1]Department of Surgery, St Vincent's University Hospital, Elm Park, Dublin 4, Ireland
[2]Department of Radiology, St Vincent's University Hospital, Elm Park, Dublin 4, Ireland
[3]Department of Emergency Medicine, St Vincent's University Hospital, Elm Park, Dublin 4, Ireland

Table 2. Breakdown of indeterminate findings

Indeterminate incidental finding	Number
Adnexal lesions	31
Pulmonary nodule/lesions	22
Colorectal lesions	17
Renal lesions	13
Liver lesions	12
Adrenal lesions	10
Gastric lesions	9
Pancreatic lesions	8
Lymphadenopathy	6
Oesophageal lesions	4
Bone lesions	5
Gallbladder thickening	3
Bladder lesions	3

Table 1. Summary of incidental findings encountered at emergency CT ($N = 700$)

	Finding	N
Liver	Cyst	49
	Lesion/met	18
	Haemangioma	12
	Steatosis/cirrhosis	4
Biliary	Gallstones	48
	Biliary tree dilatation	16
	Gallbladder thickening/distension	5
	Adenomyatosis	3
Pancreas	Cyst	9
	Lesion (?neoplasm/IPMN)	14
	Calcification	5
	Dilated pancreatic duct	4
Adrenal	Adrenal lesion/adenoma	46
Renal	Cyst	30
	Lesion/mass	14
	Calculus	20
	Hydronephrosis	8
	Infarct/atrophy	3
	Congenital anomaly (duplex ureters)	4
	Angiomyolipoma	4
	Horseshoe kidney	1
Bladder	Wall thickening/lesion	6
	Calculus	1
Spleen	Splenomegaly	7
	Cyst/lesion	5
Upper GI	Hiatus hernia	9
	Duodenal diverticulum	9
	Gastric lesion	11
	Oesophageal lesion	6
	Varices	2
Colorectal	Diverticulosis colon	100
	Thickened colon	15
	Malrotation	2
Gynaecology	Ovarian cyst(s)	43
	Fibroid	14
	Adnexal/pelvic mass	23
	Congenital anomaly	4
Pulmonary	Lesion/met	22
	Pneumonia/effusion	11
	Fibrosis	4
	PE	5
	Pleural plaques	4
Vascular	Abdominal aortic aneurysm	19
	Common iliac aneurysm	12
	Splenic artery aneurysm	7
	Thrombosis (SMA, PV, SV,IVC)	10
Other	Hernia	13
	Lymphadenopathy	11
	Vertebral compression fractures	4
	Bony abnormality	4

700 patients. Though the vast majority (79.5%, n = 557) was benign.

11% additional workload effect as a result of the initial emergency.

The Journal of Emergency Medicine, Vol. ■, No. ■, pp. 1–7, 2017

0736-4679/$ - see front matter

ELSEVIER

http://dx.doi.org/10.1016/j.jemermed.2017.08.003

Original Contributions

INCIDENTAL FINDINGS ON PEDIATRIC ABDOMINAL COMPUTED TOMOGRAPHY AT A PEDIATRIC TRAUMA CENTER

Youanna Daoud, MD,* Alexander Philip, MD,† Gal Altberg, MD,† Hadassa Leader, MD,* Jeremy Neuman, MD,‡ and Barry Hahn, MD†

*Department of Pediatrics, Staten Island University Hospital, Northwell Health, Staten Island, New York, †Department of Emergency Medicine, Staten Island University Hospital, Northwell Health, Staten Island, New York, and ‡Department of Radiology, Staten Island University Hospital, Northwell Health, Staten Island, New York

Corresponding Address: Barry Hahn, MD, Department of Emergency Medicine, Staten Island University Hospital, 475 Seaview Ave, Staten Island, NY 10305

☐ **Abstract—Background:** The increasing availability and use of computed tomography (CT) in pediatric abdominal trauma has increased the detection of incidental findings. While some of these findings are benign, others may require further evaluation for possible clinical importance. **Objectives:** This study aimed to identify the frequency and type of incidental findings and their need for follow-up on abdominal CT in patients at a pediatric trauma center. **Methods:** This was a retrospective, observational study on trauma patients ≤21 years of age who presented to the emergency department between January 1, 2004 and July 31, 2016 and underwent CT scans of the abdomen and pelvis. Findings were classified as benign anatomic variants, benign pathologic lesions, and pathologic lesions requiring additional work-up. **Results:** There were 1073 patients included in the study population, with a mean age of 15.5 years; 707 (66%) were males. A total of 418 incidental findings were identified in 345 patients. Of these, 290 (69%) were benign and 60 (14%) were likely benign pathologic that required possible outpatient monitoring. Of those requiring additional evaluation, 5 (1%) patients warranted further evaluation before discharge. **Conclusions:** Nearly one-third of patients had at least one radiographic finding unrelated to their injury. Of these, more than two-thirds did not require additional evaluation, but nearly one-third of patients required some form of further work-up.

☐ **Keywords—CT scan; incidental findings; trauma**

INTRODUCTION

Pediatric trauma cases have increased over the past several years, becoming one of the leading causes of morbidity and mortality in the pediatric population (1). Approximately 80% of pediatric trauma cases are related to blunt abdominal trauma (2). In such pediatric abdominal trauma cases, there had been an increasing use and availability of computed tomography (CT), which is both sensitive and accurate in determining the exact location and extent of an injury. Although current literature suggests a decreased utilization of CT in hemodynamically stable patients, until recently, according to the Eastern Association for the Surgery of Trauma, despite the risk of radiation, CT remains the imaging modality of choice in hemodynamically stable patients whose initial physical examination is suggestive of abdominal injury (3–5).

The increased use of imaging in the medical field has led to increased detection of incidental findings, which can be benign without health risks. However, some may require follow-up and others may require urgent

Reprints are not available from the authors.

Paediatric age groups

- Over 10% of CT scans in the world are made on patients aged less than 18 years (1).
- About 3% of all CT scans done annually in Japan , 11% in the US are performed in children (1)
- Currently, approximately 33% of all pediatric CT examinations are performed in children in the first decade of life, with 17% in children at or under the age of five years.
- Most pediatric CT examinations are for imaging of the cranium and body trunk.(2)

1.UNSCEAR (2000) Sources and effects of ionizing radiation. Volume I: Sources. UNSCEAR 2000 Report. United Nations Scientific Committee on the Effects of Atomic Radiation. 2000 Report to the General Assembly, with scientific annexes. United Nations, New York

2.Radiation Risks from Pediatric Computed Tomography Scanning

Gabriel Chodick et al. Pediatr Endocrinol Rev. 2009 December ; 7(2): 29–36.

Why radiation sensitive children?

- Children's longer life expectancy from the time of exposure, which provides more time for a cancer to manifest.
- Their longer latency period, many radiation-induced malignancies, particularly solid cancers.
- Radiation effects on proliferating cells
- Growing children have more dividing cells, and hence greater radiation sensitivity than adults.

- Pediatric CT radiation exposure: where we were, and where we are now
Thomas R. Goodman et al.Pediatric Radiology (2019) 49:469–478

Estimated risk for paediatric patients

- Estimates of the risk of future malignancy in pediatric patients receiving CT scans vary.
- One study assessed the risks of developing a fatal cancer from CT scanning and estimated the lifetime attributable cancer mortality risk attributable to ;
- A single radiation exposure in a one year-old child to be 1 in 550 following an abdominal CT and 1 in 1500 following a brain CT.(1)

- Adolescent girls undergoing breast development have higher breast radiosensitivity compared with younger children or adult women. Adolescents also have higher thyroid radiosensitivity.

1.Brenner D et al.Estimated risks of radiation-induced fatal cancer from pediatric CT.AJR Am J Roentgenol 2001;176:289

Pediatric Radiology (2019) 49:469–478
https://doi.org/10.1007/s00247-018-4281-y

MINISYMPOSIUM: QUALITY AND SAFETY

CrossMark

Pediatric CT radiation exposure: where we were, and where we are now

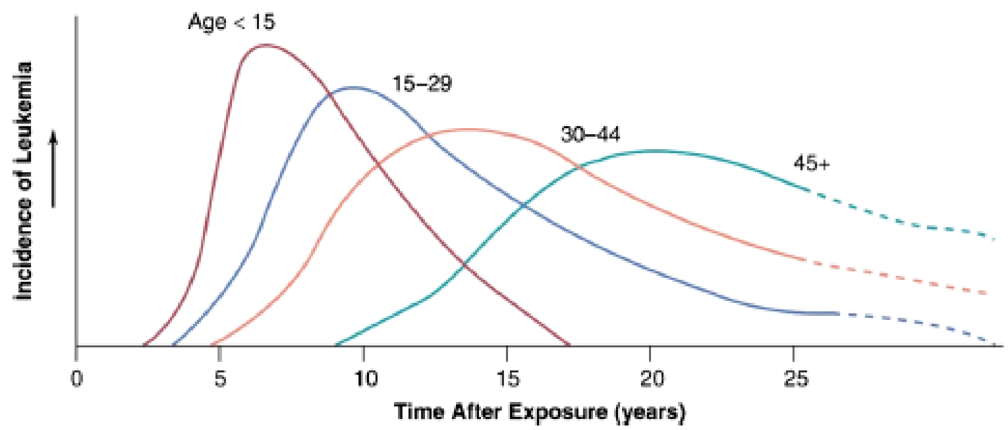
Thomas R. Goodman [1] · Adel Mustafa [1] · Erin Rowe [1]

Table 1 Effect of age at time of exposure and gender on excess cancers: risk ratios obtained from Fig. 3 and calculated for 0, 5 and 15 years old to that at 30 years old at time of exposure

	Newborn compared to 30 years old		5 years compared to 30 years old		15 years compared to 30 years old	
	F	M	F	M	F	M
Cancer incidence	4.58	3.86	3.26	2.77	1.98	1.78
Cancer mortality	3.49	3.24	2.64	2.46	1.75	1.68

F female, *M* male

Fig. 1 Incidence of all forms of leukemia (except chronic lymphocytic leukemia) and the effect of age at the time of exposure among the atomic bomb survivors [7, 10]. (Reprinted with permission from Wolters Kluwer)



Trauma/academic centers

ORIGINAL ARTICLE **CLINICAL PRACTICE MANAGEMENT**

CrossMark

SA-CME

Injured Children Receive Twice the Radiation Dose at Nonpediatric Trauma Centers Compared With Pediatric Trauma Centers

Rosemary Nabaweesi, DrPH, MBChB, MPH[a,b], Raghu H. Ramakrishnaiah, MD[c], Mary E. Aitken, MD, MPH[a,b], Mallikarjuna R. Rettiganti, PhD[b,f], Chunqiao Luo, MS[b,f], Robert T. Maxson, MD[d], Charles M. Glasier, MD[c], Phillip J. Kenney, MD[e], James M. Robbins, PhD[a,b]

Abstract

Background: Use of cranial CT scans in children has been increasing, in part due to increased awareness of sports-related concussions. CT is the largest contributor to medical radiation exposure, a risk factor for cancer. Long-term cancer risks of CT scans can be two to three times higher for children than for adults because children are more radiosensitive and have a longer lifetime in which to accumulate exposure from multiple scans.

Study Aim: To compare the radiation exposure injured children receive when imaged at nonpediatric hospitals (NPHs) versus pediatric hospitals.

Methods: Injured children younger than 18 years who received a CT scan at a referring hospital during calendar years (CYs) 2010 and 2013 were included. Patient-level factors included demographics, mode of transportation, and Injury Severity Score, and hospital-level factors included region of state, radiology services, and hospital type and size. Our primary outcome of interest was the effective radiation dose.

Results: Four hundred eighty-seven children were transferred to the pediatric trauma center during CYs 2010 and 2013, with a median age of 7.2 years (interquartile range 5-13). The median effective radiation dose received at NPHs was twice that received at the pediatric trauma center (3.8 versus 1.6 mSv, $P < .001$). Results were confirmed in independent and paired analyses, after controlling for mode of transportation, emergency department disposition, level of injury severity, and at the NPH trauma center level, hospital type, size, region, and radiology services location.

Conclusion: NPHs have the potential to substantially reduce the medical radiation received by injured children. Pediatric CT protocols should be considered.

Key Words: Effective radiation dose, nonpediatric hospitals, CT scan

J Am Coll Radiol 2018;15:58-64. Copyright © 2017 American College of Radiology

- Children who were initially evaluated for appendicitis in a community hospital were **about 4.5 times more likely to have a CT scan** and were less likely to have an abdominal US as compared to an academic center.

- Saito JM et al. Use and accuracy of diagnostic imaging by hospital type in pediatric appendicitis. Pediatrics. 2013;131(1):e37--44.

Overuse of CT in paediatric emergency departments

Teaching hospitals Vs. Non-teaching facilities	
Hoshiko et al. (16)	An earlier and more considerable decline in CT rates was demonstrated in teaching hospitals during the study period (2005-2012).
Marin et al. (43)	Non-academic non-paediatric EDs had higher odds of using any type of CT during injury-related visits (OR = 1.51, 95% CI = 1.16 to 1.96).
Saito et al. (89)	Children who were initially evaluated for appendicitis in a community hospital were about 4.5 times more likely to have a CT scan and were less likely to have an abdominal US as compared to an academic center.
Blackwell et al. (55)	This study demonstrated no differences in CT use between teaching and non-teaching facilities (21% CT usage rate in each).
Paediatric-specific facilities Vs. General hospitals	
Adelgais et al. (17)	Cervical spine CT usage has increased particularly in children originally assessed at general EDs (from 6.8% to 42.0%), as compared to patients in paediatric specific facilities (from 3.5% to 16.1%) between 2002-2011.
Wylie et al. (10)	Paediatric training and higher paediatric volumes were associated with less frequent use of head CT.
Blackwell et al. (55)	CT was used more frequently in general EDs (22%) than in paediatric-specific EDs (13%) during the study period (1995-2003).
Neff et al. (87)	Patients who initially presented at a referral hospital were more likely to undergo CT scan for presumed acute appendicitis than patients presented at a children's hospital. In addition, the Alvarado score has been effective in preventing unneeded CT scans in the children's hospital, but was not taken into account in the referral hospitals.
Michailidou et al. (88)	Children that presented at a referral institution with acute abdominal pain had a 5-fold larger likelihood to receive a CT scan, compared to children presented at a paediatric ED.

- General hospitals,
- non academic hospitals,
- Non-trauma centers,

provide more radiation to the children.

Orly Ohana et al.British Instutite of Radiology,Review Article,2017,doi.org/10.1259/bjr.20170434

Geriatric patients

- According to the National Hospital Ambulatory Care Survey in 2011, nearly 15% of all ED visits were by patients older than 65 years.
- After chest pain and shortness of breath, abdominal pain is the third most common chief complaint in patients older than 65 years who present to the ED.
- These diseases are more complex, in both presentation and treatment, in geriatric patients than younger counterparts.
- Geriatric patients seen in the ED for abdominal pain
  - have higher rates of admission, up to 60%
  - longer length of stays in the ED and inpatient units when admitted.

National Center for Health Statistics. Health, United States, 2014. Hyattsville (MD): U.S. Department of Health and Human Services; 2014

Geriatric patients

Table 1
Imaging modalities for geriatric patients with abdominal pain

Imaging in Abdominal Pain in the Elderly

Modality	Pros	Cons	Ideal for Evaluation of
Plain Radiographs	• Portable • Widely available • Quick to interpret • Economical	• Lacks sensitivity and specificity compared with other modalities	• Bowel obstruction • Foreign body identification • Free intraperitoneal air (if of sufficient quantity)
CT Scan	• High sensitivity and specificity for numerous abdominal conditions • Quickly accomplished	• May require nephrotoxic contrast • May not be readily available	• Abdominal aortic aneurysm • Appendicitis • Diverticular disease • Bowel obstruction
Ultrasound	• Portable • No contrast required	• Operator-dependent • Body habitus limitations	• Gallbladder disease • Abdominal aortic aneurysm • Bowel obstruction
MRI	• High-resolution images • Avoidance of nephrotoxic contrast	• Not readily available • Time consuming • Expensive	• Diverticular disease • Abdominal aortic aneurysm
Angiography	• Useful in both diagnosis and treatment	• Invasive • Nephrotoxic contrast	• Mesenteric ischemia

- Geriatric patients admitted for abdominal pain, nearly 20% underwent an invasive procedure or surgery.
- More charges and cost the health care system compared with younger patients.
- Of those geriatric patients presenting to the ED for abdominal pain who undergo surgical intervention, 17% will die, with mortality approaching 40% for patients older than 80 years.

Pregnancy

- The European Society of Urogenital Radiology (ESUR) and the American College of Radiology (ACR) recommend to perform magnetic resonance imaging (MRI) after indeterminate US, and to only use computed tomography when MRI is not available.(1)
- They did not give any recommendation with regard to the CT protocols(2)

1.Masselli G et al.Acute abdominal and pelvic pain in pregnancy: ESUR recommendations. Eur Radiol 2013,23: 3485–3500

2.Smith MP et al.2015 ACR appropriateness Criteria® right lower quadrant pain—suspected appendicitis.Ultrasound Q 31:85–91

European Radiology
https://doi.org/10.1007/s00330-018-5573-1

EMERGENCY RADIOLOGY

Suspicion of appendicitis in pregnant women: emergency evaluation by sonography and low-dose CT with oral contrast

Pierre-Alexandre Poletti[1] · Diomidis Botsikas[1] · Minerva Becker[1] · Marlise Picarra[1] · Olivier T. Rutschmann[2] · Nicolas C. Buchs[3] · Habib Zaidi[1] · Alexandra Platon[1]

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Abstract

Objectives To evaluate non-intravenously enhanced low-dose computed tomography with oral contrast (LDCT) for the assessment of pregnant women with right lower quadrant pain, when magnetic resonance imaging (MRI) is not immediately available.

Methods One hundred and thirty-eight consecutive pregnant women with acute abdominal pain were admitted in our emergency centre. Thirty-seven (27%) of them, with clinical suspicion of acute appendicitis, underwent abdominal ultrasonography (US). No further examination was recommended when US was positive for appendicitis, negative with low clinical suspicion or showed an alternative diagnosis which explained the clinical presentation. All other patients underwent LDCT (<2.5 mSv). Standard intravenously enhanced CT or MRI was performed when LDCT was indeterminate.

Results Eight (22%) of 37 US exams were reported normal, 25 (67%) indeterminate, 1 (3%) positive for appendicitis, 3 (8%) positive for an alternative diagnosis. LDCT was obtained in 29 (78%) patients. It was reported positive for appendicitis in 9 (31%), for alternative diagnosis in 2 (7%), normal in 13 (45%) and indeterminate in 5 (17%). Further imaging (standard CT or MRI) showed appendicitis in 2 of these 5 patients, was truly negative in 1, indeterminate in 1 and falsely positive in 1. An appendicitis was confirmed at surgery in 12 (32%) of the 37 patients. The sensitivity and the specificity of the algorithm for appendicitis were 100% (12/12) and 92% (23/25), respectively.

Conclusions The proposed algorithm is very sensitive and specific for detection of acute appendicitis in pregnant women; it reduces the need of standard CTs when MRI is not available as second-line imaging.

Key points

Artificial intelligance(AI) on CT

Pesapane et al. European Radiology Experimental (2018) 2:35
https://doi.org/10.1186/s41747-018-0061-6

European Radiology Experimental

NARRATIVE REVIEW Open Access

Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine

Filippo Pesapane[1†], Marina Codari[2*†] and Francesco Sardanelli[2,3]

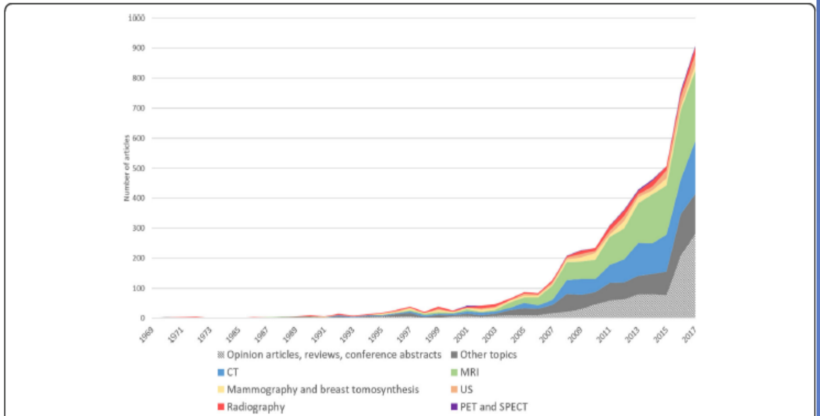

Fig. 4 Number of publications indexed on EMBASE obtained using the search query ('artificial intelligence'/exp. OR 'artificial intelligence' OR 'machine learning'/exp. OR 'machine learning' OR 'deep learning'/exp. OR 'deep learning') AND ('radiology'/exp. OR 'radiology' OR 'diagnostic imaging'/exp. OR 'diagnostic imaging') AND ([english]/lim). EMBASE was accessed on April 24, 2018. For each year the number of publications was stratified for imaging modality. *US* ultrasound, *MRI* magnetic resonance imaging, *CT* computed tomography, *PET* positron emission tomography, *SPECT* single-photon emission tomography. Diagnostic modalities different from those listed above are grouped under the "other topic" label (e.g. optical coherence tomography, dual-energy x-ray absorptiometry, etc.)

Table 1 Number of articles on AI in radiology indexed on EMBASE, stratified by imaging modality

Imaging modality	2015	2016	2017
Magnetic resonance imaging	164	230	235
	38%	42%	37%
Computed tomography	123	117	177
	29%	21%	28%
Ultrasound	27	32	33
	6%	6%	5%
Radiography	14	14	26
	3%	3%	4%
Mammography and breast tomosynthesis	23	12	18
	5%	2%	3%
Positron emission tomography and single-photon emission tomography	1	7	5
	0%	1%	1%
Other	79	139	134
	18%	25%	21%
Total	431	551	628
	100%	100%	100%

- Machine learning
- Big data
- Automated report generation
- Multimodality image analysis
- Publicly available datasets
- Competitive challenges

AJR FOCUS ON:

Progress in Fully Automated Abdominal CT Interpretation

Ronald M. Summers[1]

OBJECTIVE. Automated analysis of abdominal CT has advanced markedly over just the last few years. Fully automated assessment of organs, lymph nodes, adipose tissue, muscle, bowel, spine, and tumors are some examples where tremendous progress has been made. Computer-aided detection of lesions has also improved dramatically.

CONCLUSION. This article reviews the progress and provides insights into what is in store in the near future for automated analysis for abdominal CT, ultimately leading to fully automated interpretation.

Unlike for images of the brain and breast, automated analysis of images of the abdomen has been a relative latecomer to radiology. However, the pace of innovation for automated abdominal image analysis has accelerated in just the last few years. Much of this progress has focused on CT, the workhorse of abdominal diagnosis. For example, in a concerted effort over the last 15 years, great progress was made in image processing of CT colonography, leading to such advances as virtual colonoscopy flythrough and computer-aided detection (CAD) of polyps. Beginning in the same time frame and extending to the present, numerous articles describe methods to automatically detect, quantitate, and classify imaging findings on routine abdominal CT. These advances are moving the field closer to achieving the promise of fully automated image analysis and interpretation [1, 2].

Automated image analysis will be considered here in the broadest sense, including quantitative analyses and CAD and classification of disease. This review will cover the broad swath of applications in the abdomen, including organ, lymph node, adipose tissue, muscle, bowel, spine, and tumor analysis. Some speculations about the future of this dynamic field will conclude the review.

Overview

Radiologists perform numerous high-level tasks when interpreting abdominal CT images. These tasks include assessment of organs and detection, classification, and measurement of lesions. Incidental findings must be considered and accepted or rejected. The findings must be put into the proper clinical context of the particular patient. For example, the knowledge that a patient has cancer influences the classification of a new lesion as metastatic versus infectious or inflammatory.

Each of these tasks is amenable to automation. Organs can be located by the computer using atlas- and landmark-based methods. Organ volume and shape can be assessed by finding the edges of the organs in three dimensions, a process known as segmentation. Lesions can be detected and segmented by assessing the patterns of Hounsfield unit intensities in the organs to identify anomalies. Example patterns include variations in intensities, texture, and shape. The quantitative measurements of these patterns are known as features.

To perform accurate detection and segmentation, organs and lesions must be distinguished from other surrounding tissues to avoid false recognition. To do so, features calculated for organs, lesions, and surrounding tissues are fed into classifiers to teach the computer how to distinguish them. The final outputs include those useful for diagnosis (true-positives) and incorrect ones that are not useful (false-positives). At the present time, for most applications, the computer always produces false-positives, necessitating radiologist review. However, the number of false-positives is steadily decreasing as the computer techniques improve.

There are two approaches to developing accurate automated radiologic image analy-

Keywords: computer-aided detection, CT, image processing, CT, segmentation, volumetrics

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[1]Imaging Biomarkers and Computer-aided Diagnosis Laboratory, Radiology and Imaging Sciences, National Institutes of Health Clinical Center, Bldg 10, Rm 1C224D, MSC 1182, Bethesda, MD 20892-1182. Address correspondence to R. M. Summers (rms@nih.gov).

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Artificial intelligence of Abdominal CT

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MINIREVIEWS

Artificial intelligence in medical imaging of the liver

Li-Qiang Zhou, Jia-Yu Wang, Song-Yuan Yu, Ge-Ge Wu, Qi Wei, You-Bin Deng, Xing-Long Wu, Xin-Wu Cui, Christoph F Dietrich

ORCID number: Li-Qiang Zhou (0000-0002-6025-2694); Jia-Yu Wang (0000-0001-9902-0666); Song-Yuan Yu (0000-0003-3563-1884); Ge-Ge Wu (0000-0002-7159-2483); Qi Wei (0000-0002-7955-406X); You-Bin Deng (0000-0001-8002-5109); Xing-Long Wu (0000-0001-9778-0864); Xin-Wu Cui (0000-0003-3890-6660); Christoph F Dietrich (0000-0001-6015-6347).

Author contributions: Cui XW established the design and conception of the paper; Zhou LQ, Wang JY, Yu SY, Wu GG, Wei Q, Deng YB, Wu XL, Cui XW, and Dietrich CF explored the literature data; Zhou LQ provided the first draft of the manuscript, which was discussed and revised critically for intellectual content by Zhou LQ, Wang JY, Yu SY, Wu GG, Wei Q, Deng YB, Wu XL, Cui XW, and Dietrich CF; all authors discussed the statement and conclusions and approved the final version to be published.

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Li-Qiang Zhou, Jia-Yu Wang, Ge-Ge Wu, Qi Wei, You-Bin Deng, Xin-Wu Cui, Christoph F Dietrich, Sino-German Tongji-Caritas Research Center of Ultrasound in Medicine, Department of Medical Ultrasound, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, Hubei Province, China

Song-Yuan Yu, Department of Ultrasound, Tianyou Hospital Affiliated to Wuhan University of Technology, Wuhan 430030, Hubei Province, China

Xing-Long Wu, School of Mathematics and Computer Science, Wuhan Textitle University, Wuhan 430200, Hubei Province, China

Christoph F Dietrich, Medical Clinic 2, Caritas-Krankenhaus Bad Mergentheim, Academic Teaching Hospital of the University of Würzburg, Würzburg 97980, Germany

Corresponding author: Xin-Wu Cui, MD, PhD, Professor of Medicine, Sino-German Tongji-Caritas Research Center of Ultrasound in Medicine, Department of Medical Ultrasound, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, No. 1095, Jiefang Avenue, Wuhan 430030, Hubei Province, China. cuixinwu@live.cn
Telephone: +86-15927103161
Fax: +86-27-83662640

Abstract

Artificial intelligence (AI), particularly deep learning algorithms, is gaining extensive attention for its excellent performance in image-recognition tasks. They can automatically make a quantitative assessment of complex medical image characteristics and achieve an increased accuracy for diagnosis with higher efficiency. AI is widely used and getting increasingly popular in the medical imaging of the liver, including radiology, ultrasound, and nuclear medicine. AI can assist physicians to make more accurate and reproductive imaging diagnosis and also reduce the physicians' workload. This article illustrates basic technical knowledge about AI, including traditional machine learning and deep learning algorithms, especially convolutional neural networks, and their clinical application in the medical imaging of liver diseases, such as detecting and evaluating focal liver lesions, facilitating treatment, and predicting liver treatment response. We conclude that machine-assisted medical services will be a promising solution for future liver medical care. Lastly, we discuss the challenges and future directions of clinical application of deep learning techniques.

Key words: Liver; Imaging; Ultrasound; Artificial intelligence; Machine learning; Deep learning

Table 1 Clinical application of artificial intelligence

n	Task	Type	Accuracy	Sensitivity	Specificity	Ref.
1	Detecting fatty liver disease and making risk stratification	Deep learning based on US	100%	100%	100%	[42]
2	Detecting and distinguishing different focal liver lesions	Deep learning based on US	97.2%	98%	95.7%	[43]
3	Evaluating liver steatosis	Deep learning based on US	96.3%	100%	88.2%	[49]
4	Evaluating chronic liver disease	Machine learning algorithm based on SWE	87.3%	93.5%	81.2%	[12]
5	Discriminating liver tumors	DCCA-MKL framework based on US	90.41%	93.56%	86.89%	[50]
6	Predicting treatment response	Machine learning algorithm based on MR	78%	62.5%	82.1%	[58]

DCCA-MKL: Deep canonical correlation analysis-multiple kernel learning; MRI: Magnetic resonance imaging; US: Ultrasound.

Future of AI for abdominal CT

Evaluation of an AI-Based Detection Software fo[r] Acute Findings in Abdominal Computed Tomography Scans

Toward an Automated Work List Prioritization of Routine CT Examinations

Winkel, David J., MD; Heye, Tobias, MD; Weikert, Thomas J., MD; Boll, Daniel T., MD; Stieltjes, Bram, MD, PhD

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Technical Notes

Abstract **Author InformatioAuthors** **Article MetriMetrics**

Objective The aim of this study was to test the diagnostic performance of a deep learning-based triage system for the detecti[on] of acute findings in abdominal computed tomography (CT) examinations.

Materials and Methods Using a RIS/PACS (Radiology Information System/Picture Archiving and Communication System) search engine, we obtained 100 consecutive abdominal CTs with at least one of the following findings: free-gas, free-fluid, or fat-stranding and 100 control cases with absence of these findings. The CT data were analyzed using a convolutional neural network algorithm previously trained for detection of these findings on an independent sample. The validation of the results was performed on a Web-based feedback system by a radiologist with 1 year of experience in abdominal imaging without pri[or] knowledge of image findings through both visual confirmation and comparison with the clinically approved, written report a[s] the standard of reference. All cases were included in the final analysis, except those in which the whole dataset could not be processed by the detection software. Measures of diagnostic accuracy were then calculated.

Results A total of 194 cases were included in the analysis, 6 excluded because of technical problems during the extraction of DICOM datasets from the local PACS. Overall, the algorithm achieved a 93% sensitivity (91/98, 7 false-negative) and 97% specificity (93/96, 3 false-positive) in the detection of acute abdominal findings. Intra-abdominal free gas was detected with 92% sensitivity (54/59) and 93% specificity (39/42), free fluid with a 85% sensitivity (68/80) and 95% specificity (20/21), a[nd] fat stranding with a 81% sensitivity (42/50) and 98% specificity (48/49). False-positive results were due to streak artifacts, partial volume effects, and a misidentification of a diverticulum (each n = 1).

Conclusions The algorithm's autonomous detection of acute pathological abdominal findings demonstrated a high diagnosti[c] performance, enabling guidance of the radiology workflow toward prioritization of abdominal CT examinations with acute conditions.

From the Department of Radiology, University Hospital Basel, Basel, Switzerland.

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Correspondence to: Thomas J. Weikert, MD, University Hospital Basel, University of Basel, Clinic of Radiology & Nuclear Medicine, Petersgraben 4, 4031 Basel, Switzerland. E-mail: thomas.weikert@usb.ch.

- Autopilots for airplanes changed the role of the pilot.
- Self-driving cars will change the role of the driver.
- In both cases, the human is still ultimately responsible for the safety of the passengers.
- Similarly, fully automated abdominal CT image interpretation is likely to change the role of radiologists, but they will still be responsible for taking care of the patient and making the final diagnosis

Summary

- Management of patients:universal algoritm’s
- Good medical practice
- No amount of radiation should be considered absolutely safe.
- Special ages group,more attention
- Higher benefits than harm in ED(life threating conditions)

- Thank you for your attention.