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FULL PAPER

The prevalence and significance of thoracic findings in patients undergoing extended coverage computed tomography for assessment of abdominal aortic aneurysms

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Objective: Many major vascular centres, including ours, incorporate coverage of the thoracic aorta in CT scans evaluating abdominal aortic aneurysms (AAAs) [extended coverage contrast-enhanced CT (EC-CECT) scan]. We sought to determine the prevalence of thoracic pathology in a large consecutive series of patients with AAA undergoing EC-CECT.

Methods: All patients who underwent EC-CECT for AAA between April 2013 and 2014 were identified from our radiology information system. Reports were retrospectively reviewed and for each study, sex, age and reported thoracic aortic and other non-vascular findings were extracted. Findings were initially categorized into “major” or “minor” depending on if they were mentioned in the report impression/conclusion. Any major thoracic pathology was termed “significant” if there was a new diagnosis/patient intervention/investigation and a change in patient management.

Results: Of the 150 scans included in the study, 97 (65%) had at least one thoracic finding. These findings included 24 scans (16%) with major findings and 73 scans (48%) with minor findings. In 13 scans (9%), the findings were significant and resulted in a delay ($n = 11$) or cancellation ($n = 2$) of AAA repair.

Conclusion: Pre-procedural EC-CECT helps to identify significant intrathoracic findings in patients with AAA, which can have a major impact on AAA repair. This study supports the routine use of pre-procedural EC-CECT in planning AAA repair.

Advances in knowledge: This study describes the prevalence of significant thoracic pathology, which can impact on AAA repair. This information could potentially change the pre-procedure imaging protocol for patients with AAA.

INTRODUCTION

Abdominal aortic aneurysms (AAAs) have demonstrated an increasing incidence and prevalence to emerge as one of the leading cause of deaths worldwide. In the USA, it is documented in 5–7% of the population older than 60 years. By far, the biggest problem with AAA is that of rupture, with approximately 9000 AAA-related deaths occurring annually in patients aged over 55 years in the USA.^{1,2} Over the years, advances in techniques of AAA repair, both endovascular and open, have shown significant reduction in operating times, intraoperative blood loss and perioperative morbidity and mortality.³ Various factors contribute to the successful repair of AAAs; prime among them being pre-procedure imaging and planning. Over the years, contrast-enhanced CT has become a well-established modality for pre-procedural imaging and planning.³ What vary between different vascular centres are the parameters of the scanning

technique. Most centres resort to pre-operative scanning of the abdomen and pelvis only. Select vascular centres, adept at fenestrated endovascular repair of AAAs, prefer to extend coverage in pre-operative imaging to include the thoracic aorta [extended coverage contrast-enhanced CT scan (EC-CECT)]. The theory is that of characterizing any pathology in the thoracic aorta in the same sitting to allow appropriate pre-operative planning of fenestrated/thoracic endovascular aneurysm repair if required. Another theory is that of quantifying any intrathoracic pathology that could affect/delay aneurysm repair.

Birmingham Heartlands Hospital (BHH) is one of the UK centres for fenestrated endovascular aneurysm repair, and we apply the EC-CECT protocol for pre-operative planning. At BHH, we decided to investigate the efficacy and scope of this protocol, by characterizing the prevalence of

intrathoracic findings in EC-CECT performed for patients with AAA at our institution. Our search revealed limited published literature on this specific topic.

METHODS AND MATERIALS

Patients

All patients with AAA who underwent EC-CECT at our institution, which is a major regional vascular surgical centre, between April 2013 and April 2014 were identified from the radiology information system using local codes. The cohort of study patients were identified from this group after applying the inclusion and exclusion criteria as outlined in Table 1. A fellowship-trained vascular radiologist (AG), with more than 5 years' of experience, had interpreted all studies, and the reports were retrospectively reviewed. For each study, sex, age and reported thoracic aortic and other non-vascular findings were extracted. This retrospective study was approved by the local hospital research and ethics committee and informed consent was waived.

Patient selection, scan protocol and post-processing

All patients undergoing EC-CECT had blood tests carried out to check serum creatinine and glomerular function rate. Patients with renal impairment ($\text{eGFR} < 60 \text{ ml min}^{-1}$) received pre-hydration with intravenous crystalloids (according to the European Society of Urogenital Radiology guidelines).⁴ Patients with iodinated contrast allergy received a different imaging modality (e.g. MRI, ultrasound) and, as such, were excluded from this study.

EC-CECT involved scanning from lung apices to both groins. Images were obtained, with the patient supine and the arms raised above the shoulders, on a Toshiba® Aquilion™ 320-slice multidetector CT scanner (Toshiba Medical Systems, Tokyo, Japan). Slice acquisition was in helical mode at pitch of 65. The tube voltage was set at 120 kV and tube current was modulated according to the patient body mass index. Detector collimation was set at $0.5 \times 80 \text{ mm}$ with a gantry rotation time of 0.5 s. Each patient received a pre-contrast and aortogram phase sequence, with the same coverage. Contrast volume of 100 ml was injected through a pump at a rate of 3.5 ml s^{-1} , with bolus triggering off the descending thoracic aorta. Image reconstruction was in 1 mm slice thickness at 0.8-mm intervals.

Image interpretation was carried out on a picture archiving and communication system (PACS) enabled workstation, using multi-planar reconstruction and volume rendering software.

Data analysis

Any thoracic pathology reported was classified into "major" and "minor" findings. Pathology was classified as major if it was referenced in the impression/conclusion section of report (e.g. lung cancer, lymphadenopathy in the presence of suspicious lung lesion, pleural effusions overlying areas of collapse/consolidation etc.); the reasoning being that the reporting radiologist considered the finding important enough to notify the clinical team, potentially triggering a follow-up/investigation or intervention. Minor pathology was considered as that not mentioned in the impression/conclusion (e.g. trace or simple pleural/pericardial effusion, hiatus hernia etc.) but mentioned in the body of the report. Once again, a host of thoracic findings frequently are mentioned in reports but do not warrant any further investigation/intervention.

To assess the clinical impact of major pathology, the patient's electronic medical records were reviewed. Follow-up was deemed to have occurred if a subsequent imaging study was performed to further evaluate this finding. A finding was considered "known" if it was referenced in a previous imaging report. These findings were further classified as "significant" only if it resulted in a new diagnosis/further intervention/treatment, which delayed or cancelled the planned aneurysm repair.

Statistics

All data were collated using Microsoft® Excel® (Microsoft, Redmond, WA) software. Absolute number as well as percentage described prevalence. Findings were presented as mean $\pm$ standard deviation where appropriate. Two-tailed comparisons were performed using the Student's *t*-test for normally distributed data. Statistical significance was set at *p*-value < 0.05 .

RESULTS

A total of 364 studies were identified from the database from which 150 studies could be recruited into the study. The male:female ratio was 113:37 (75% male). The age range was 48–98 years (mean $\pm$ standard deviation = 75.6 ± 8.8 , median = 75 and mode = 69).

Continuous data were found to follow normal distribution. With the Student's *t*-test, no significant difference was seen in patients with major intrathoracic pathology and without, with respect to age ($p = 0.27$) and gender ($p = 0.71$).

A total of 128 thoracic findings were reported in 97 studies (97/150, 64%). These included 34 major findings in 24 studies (24/150, 16%) and 94 minor findings in 73 studies (73/150, 48%).

Table 1. Inclusion and exclusion criteria for patients identified from local radiology information system having had "CT aortogram"

Inclusion criteria	Exclusion criteria
(1) Elective scans for first diagnosis of AAA	(1) Had their pre-operative planning scan without CT thorax
(2) Elective scans for surveillance of known patients with AAA carried out more than a year after previous scan	(2) Follow-up CT scans post aneurysm repair
(3) Emergency scans to diagnose ruptures in known patients with AAA	

AAA, abdominal aortic aneurysm.

Table 2. “Major” findings ($n = 34$) in 24 studies tabulated into broad categories (absolute value, percentage), including individual findings

Category of finding ($n/\%$)	Individual findings
Diffuse lung parenchymal abnormalities (3/8)	1—advanced COPD, 1—advanced fibrosis, 1—consolidation
Focal lung parenchymal abnormalities (10/30)	3—lung masses, 4—spiculated lung lesion, 2—lung nodules, 1—pulmonary sequestration
Vascular, thoracic aorta (10/30)	1—multifocal aneurysms, 4—ascending aorta aneurysm, 5—descending aorta aneurysm
Pleural abnormality (5/16) ^a	3—parapneumonic effusion, 2—effusion with underlying collapse
Vascular, other (4/10)	1—left subclavian stenosis, 1—chronic PE, 1—dilated main pulmonary artery, 1—aortic root dilatation
Mediastinal abnormalities (2/6)	1—lymphadenopathy, ^b 1—coronary artery disease

COPD, chronic obstructive pulmonary disease.

^aPleural effusion was considered major finding when part of pathology like overlying collapse/consolidation, unlike simple pleural effusion.

^bLymphadenopathy in presence of suspicious lung lesion is considered major finding.

The percentage distribution of major findings is as tabulated in Table 2, most of which were lung parenchymal masses/nodules ($n = 10$, 29%) and thoracic aortic aneurysms ($n = 10$, 29%). The percentage distribution of minor findings is as shown in Figure 1. The most common of which were lung parenchymal abnormalities, such as emphysema, apical fibrosis etc. ($n = 71$, 76%) and pleural abnormalities ($n = 7$, 8%).

Of the studies with major findings, there were five studies with findings of thoracic aortic aneurysms that were deemed not significant as their diagnoses were previously known ($n = 2$, 8%) or their aneurysms were not large enough to warrant intervention ($n = 3$, 13%). One study (4%) had a focal lung pathology that was diagnosed as a benign pulmonary sequestration

on subsequent review. Two studies, one with a thoracic aortic aneurysm and another with a spiculated lung lesion, had their procedure cancelled owing to other reasons (1—small aneurysm size and 1—pre-existing cardiorespiratory comorbidities). Three studies (1—coronary artery disease with cardiomegaly, 1—left subclavian stenosis and 1—pulmonary hypertension with pericardial effusion) had a new diagnosis and were referred to appropriate outpatient teams, but this did not delay or cancel their AAA repair. The remaining 13 studies with major findings resulted in further investigation/intervention, which delayed or cancelled AAA repair, hence were classified as significant (prevalence 9%). These scans demonstrated 18 findings, including 7 patients (47%) with a new diagnosis of biopsy-proven non-small-cell lung cancer. The significant findings were as

Figure 1. Percentage distribution of “minor” intrathoracic pathology identified on extended coverage contrast-enhanced CT scan in patients with abdominal aortic aneurysms. COPD, chronic obstructive pulmonary disease.

Table 3. “Significant” findings ($n = 18$), in 13 studies, tabulated into broad categories (absolute value/percentage), including individual findings; the third column mentions outcomes of these individual patients

Category of finding ($n/\%$)	Individual findings	Outcome
Focal lung parenchymal abnormalities (12/66)	3—lung masses, 9—lung nodules	Await thoracic MDT opinion
Vascular, thoracic aorta (4/22)	1—multifocal aneurysm, 1—ascending aorta aneurysm, 2—descending aorta aneurysms	Thoracic stent graft planned later date
Diffuse lung parenchymal abnormality (1/5)	1—consolidation	Referred to vascular MDT after infection treated
Vascular, others (1/5)	1—chronic PE	Awaiting cardiac ECHO

ECHO, echocardiogram, MDT, multidisciplinary team meeting; PE, pulmonary embolus.

tabulated in Table 3. Of these 13 studies with significant findings, AAA repair was cancelled in 2 patients (13%) owing to lung malignancies. The remaining 11 patients (61%) had their AAA repair postponed due to the significant finding. Examples of scans with significant findings are as illustrated in Figures 2–6.

DISCUSSION

Although AAA repair has undergone tremendous advances making it much safer than before, it still remains a major procedure with significant consequences for the patient. Pre-procedure imaging, planning and patient assessment therefore are integral to ensure procedural success.⁵ A host of aneurysmal and non-aneurysmal factors can have a direct impact on procedural planning and its success.

As far as defining the extent of major and significant findings, we found the definitions in the study published by Atalay *et al*,⁶ as satisfactory for the purposes of our study. Major findings according to our study were those that were important enough

to warrant highlighting to the clinical team but not always causing delay or cancellation of AAA repair. Those major findings causing delay or cancellation were classified as significant. Our decision to review the report content rather than reinterpret the images were based on the fact that the institution had only one fellowship-trained radiologist who reported all vascular imaging (AG). Also, the attempt was to understand the impact of findings in routine practice over the study period rather than analyze accuracy and discrepancies in reports.

The specific focus of our study was to analyze the prevalence of intrathoracic findings in pre-operative EC-CECT in patients with AAA and their impact on aneurysm repair in our institution. Our literature search revealed limited published reports, which differed in their definitions of major and significant findings and outcome criteria. Indes *et al*,⁷ reported 19% primary clinically significant findings in their series of 82 patients, with secondary incidental findings between 40%

Figure 2. A 69-year-old male patient with a 7-cm thoracic aortic aneurysm (solid arrow). A staged repair was planned of the thoracic and abdominal aortic aneurysms, which delayed abdominal aortic aneurysms repair.

Figure 3. A 77-year-old male patient with a spiculated right upper lobe lung lesion (solid arrow). The lesion was biopsy proven to be a non-small-cell lung cancer, and the abdominal aortic aneurysms repair was delayed for the thoracic multidisciplinary meeting decision.

Figure 4. A 82-year-old male patient with a right lower lobe lung mass (solid arrow) that was proven to be a non-small-cell lung cancer. The patient was diagnosed to have metastatic disease and aortic aneurysm repair was cancelled due to poor prognosis.

and 50%. A similar study by Kasirajan and Dayama⁸ reported 22.72% incidental findings with 4.5% metastatic neoplastic disease in 242 patients. Both these studies, however, reported both thoracic and abdominal findings. A third study by Harthun and Lau⁹ focused entirely on incidental pulmonary neoplasms and reported 18% cases with the same. The difference between the first two studies and ours was that we focused entirely on the thoracic findings with clear definitions of major and significant findings, with the hope of routine adoption of EC-CECT protocol. Another difference in our study was that we also focused on the impact of these findings on AAA repair. To our knowledge, ours is the first study to do so.

Our literature search also revealed studies reporting prevalence of incidental non-cardiac findings in patients undergoing electron-beam coronary artery or cardiac CT. The prevalence in these studies showed significant variation from 4.1% to 22.7%.^{10–13} These variations most likely reflect the heterogeneous nature of these reports. Patients receiving electron-beam CT (EBCT) for coronary calcium scoring as well as those receiving cardiac CT for acute chest pain are of a younger age group, *e.g.* 53 ± 12 years.¹⁴ Comparatively, average age in our study group was over 70 years. Although the higher average age would mean potential greater prevalence of pathology, it is also to be noted that our patients were asymptomatic from the chest pathology point of view, whereas, those in the EBCT and cardiac CT group were intermediate to high risk for thoracic disease. Another important differentiating factor was the use of contrast (EBCT vs cardiac CT). It is natural that detection of incidental findings is higher in contrast-enhanced scans. Horton et al¹⁵ demonstrated significant, extracardiac findings in 8% of 1326 EBCT examinations; however, significant was defined as any scan that

required clinical or imaging follow-up. The percentage of scans that would have ended up with a proven pathology would be smaller than that stated. A similar study by Hunold et al¹⁶ reported 9% of 1812 EBCT examinations that needed further testing, with no further mention of proven pathology. Schragin et al¹⁰ reported a lower prevalence of significant extracardiac findings (4.2%) in 1356 EBCT studies. Compared with these studies, our study had a higher percentage (9%) of findings that had either cancelled or delayed AAA repair, quite likely due to the greater thoracic coverage and contrast enhancement. Based on these factors, scan parameters in our study were more akin to a contrast-enhanced cardiac CT scan. Dewey et al¹² reported a 5% extracardiac significant finding rate in their cohort of 108 cardiac CT scans.¹¹ Mueller et al¹⁷ reported 13% significant extracardiac findings, however, their cohort of 259 patients were post surgical patients being scanned to assess coronary artery bypass graft patency. Similarly, higher rates of significant incidental extracardiac findings were reported by Law et al¹⁸ and Onuma et al¹³ at 19% and 23%, respectively. Lazoura et al¹⁹ chose to classify their findings as “mild”, “intermediate” and “severe” and reported a 15% prevalence of severe non-cardiac incidental findings in their study of 1044 patients. A study by Gil et al²⁰ reported a very high prevalence of 56%, but these were not classified according to severity and possibly included non-significant findings as well. The notable point was the higher prevalence of incidental findings reported in all these studies except by Dewey et al,¹² compared with ours, which was most likely due to non-standardized classification of findings and a symptomatic patient group in the studies on cardiac CT scans. This places our rate of significant findings between those of an

Figure 5. A 79-year-old male patient diagnosed with a chronic pulmonary embolism (arrow showing right main pulmonary artery embolus) and aortic root dilatation. Decision was made to investigate patient's cardiac function further with an echocardiogram, which delayed abdominal aortic aneurysm repair.

Figure 6. A 89-year-old male patient with bilateral lower lobe consolidation (solid arrows). Abdominal aortic aneurysm repair was delayed until patient recovered from chest infection.

unenhanced EBCT scan and a contrast-enhanced cardiac CT scan, which is to be expected.

Our study also noted that patients in the age group susceptible to AAA typically had a variety of intrathoracic CT findings, both vascular and non-vascular. However, not all of them would be important enough to either qualify as a major finding or be significant. This is reflected in our major finding rate of 16%, which although not very high, is still relevant as more than half

of these findings went on to be significant (54%). The vascular surgical view is that to plan, repair and follow-up a patient with AAA involves high-cost resources, and knowledge of any pathology that could potentially limit the life span of the stent-graft is valuable. Another argument is that of radiation dose to the patient. Over the years, a variety of strategies (prospective gating, tube current modulation, low-voltage scanning, iterative reconstruction etc.) have allowed significant dose reduction in CT scans. Many of these patients also have some degree of renal impairment if not end stage renal failure, and once again, CT dose reduction strategies allow successful scanning of patients with contrast volume loads as low as 60 ml.^{21,22} Other strategies for improving contrast enhancement are modulating contrast injection parameters (e.g. injection rate) and material (e.g. high iodine concentration).²³ Also, the benefit of avoiding a potentially life-threatening thoracic aneurysm rupture or intra-procedural complications outweighs the risk of contrast-induced nephropathy or the radiation exposure.

Our study is not without its limitations. The major limitation was that of a retrospective design, with low patient numbers. Our data collection was from the scan reports and relied on the report of radiologists without any image interpretation from our side. This could potentially introduce an element of collection bias. Also, the definitions of major, minor and significant findings were subjective and can be open to interpretation. From our point of view, we have made every attempt to keep the definitions and their interpretations objective to ensure uniformity.

CONCLUSION

Pre-procedural EC-CECT helps to identify significant intrathoracic findings, in patients with AAA, which can have a major impact on AAA repair. This study supports the routine use of pre-procedural EC-CECT in planning AAA repair.

REFERENCES

- Gillum RF. Epidemiology of aortic aneurysm in the United States. *J Clin Epidemiol* 1995; **48**: 1289–98. doi: [http://dx.doi.org/10.1016/0895-4356\(95\)00045-3](http://dx.doi.org/10.1016/0895-4356(95)00045-3)
- Silverberg E, Boring CC, Squires TS. Cancer statistics, 1990. *CA Cancer J Clin* 1990; **4**: 9–26. doi: <http://dx.doi.org/10.3322/canjclin.40.1.9>
- Geller SC; Society of Interventional Radiology Device Forum. Imaging guidelines for abdominal aortic aneurysm repair with endovascular stent grafts. *J Vasc Interv Radiol* 2003; **14**: S263–64.
- ESUR Contrast Media Safety Committee (CMSC). ESUR guidelines on contrast media 9.0 [updated 16 August 2015; cited 28 March 2016]. Available from: <http://www.esur.org/guidelines/>
- Walker TG, Kalva SP, Yeddula K, Wicky S, Kundu S, Drescher P, et al. Clinical practice guidelines for endovascular abdominal aortic aneurysm repair: written by the Standards of Practice Committee for the Society of Interventional Radiology and Endorsed by the Cardiovascular and Interventional Radiology Society of Europe and the Canadian Interventional Radiology Association. *J Vasc Interv Radiol* 2010; **21**: 1632–55. doi: <http://dx.doi.org/10.1016/j.jvir.2010.07.008>
- Atalay MK, Prince EA, Pearson CA, Chang KJ. The prevalence and significance of non-cardiac findings on cardiac MRI. *AJR Am J Roentgenol* 2011; **196**: 387–93. doi: <http://dx.doi.org/10.2214/AJR.09.3302>
- Indes JE, Lipsitz EC, Veith FJ, Gargiulo NJ 3rd, Privrat AI, Scher LA. Incidence and significance of non-aneurysmal-related computed tomography findings in patients undergoing endovascular aortic aneurysm repair. *J Vasc Surg* 2008; **48**: 286–90. doi: <http://dx.doi.org/10.1016/j.jvs.2008.03.057>
- Kasirajan K, Dayama A. Incidental findings in patients evaluated for thoracic aortic pathology using computed tomography angiography. *Ann Vasc Surg* 2012; **26**: 306–11. doi: <http://dx.doi.org/10.1016/j.avsg.2011.08.017>
- Harthun NL, Lau CL. The incidence of pulmonary neoplasms discovered by serial computed tomography scanning after endovascular aortic aneurysm repair. *J Vasc Surg* 2011; **53**: 738–41. doi: <http://dx.doi.org/10.1016/j.jvs.2010.09.066>
- Schragin JG, Weissfeld JL, Edmundowicz D, Strollo DC, Fuhrman CR. Non-cardiac findings on coronary electron beam computed tomography scanning. *J Thorac Imaging* 2004; **19**: 82–6. doi: <http://dx.doi.org/10.1016/j.jvs.2010.09.066>

- dx.doi.org/10.1097/00005382-200404000-00004
11. Haller S, Kaiser C, Buser P, Bongartz G, Bremerich J. Coronary artery imaging with contrast enhanced MDCT: extracardiac findings. *AJR Am J Roentgenol* 2006; **187**: 105–10. doi: <http://dx.doi.org/10.2214/AJR.04.1988>
 12. Dewey M, Schnapauff D, Teige F, Hamm B. Non-cardiac findings on coronary computed tomography and magnetic resonance imaging. *Eur Radiol* 2007; **17**: 2038–43. doi: <http://dx.doi.org/10.1007/s00330-006-0570-1>
 13. Onuma Y, Tanabae K, Nakazawa G, Aoki J, Nakajima H, Ibukuro K, et al. Non cardiac findings in cardiac imaging with multidetector computed tomography. *J Am Coll Cardiol* 2006; **48**: 402–6. doi: <http://dx.doi.org/10.1016/j.jacc.2006.04.071>
 14. Lehman SJ, Abbara S, Cury R, Nagurney JT, Hsu J, Goela A, et al. Significance of cardiac computed tomography incidental findings in acute chest pain. *Am J Med* 2009; **122**: 543–49. doi: <http://dx.doi.org/10.1016/j.amjmed.2008.10.039>
 15. Horton KM, Post WS, Blumenthal RS, Fishman EK. Prevalence of significant non-cardiac findings on electron-beam computed tomography coronary artery calcium screening examinations. *Circulation* 2002; **106**: 532–34. doi: <http://dx.doi.org/10.1161/01.CIR.0000027136.56615.DE>
 16. Hunold P, Schermund A, Seibel RM, Gronemeyer DH, Erbel R. Prevalence and clinical significance of accidental findings in electron-beam tomographic scans for coronary artery calcification. *Eur Heart J* 2001; **22**: 1748–58. doi: <http://dx.doi.org/10.1053/eurhj.2000.2586>
 17. Mueller J, Juedy J, Poston R, White CS. Cardiac CT angiography after coronary artery bypass surgery: prevalence of incidental findings. *AJR Am J Roentgenol* 2007; **189**: 414–19.
 18. Law YM, Huang J, Chen K, Cheah FK, Chua T. Prevalence of significant extra-coronary findings on multislice CT coronary angiography ad coronary artery calcium scoring examinations. *J Med Imaging Radiat Oncol* 2008; **52**: 49–56. doi: <http://dx.doi.org/10.1111/j.1440-1673.2007.01911.x>
 19. Lazoura O, Vassiou K, Kanavou T, Vlychou M, Arvanitis DL, Fezoulidis IV. Incidental non-cardiac findings of a coronary angiography with a 128-slice multi-detector CT scanner: should we only concentrate on the heart? *Korean J Radiol* 2010; **11**: 60–8. doi: <http://dx.doi.org/10.3348/kjr.2010.11.1.60>
 20. Gil BN, Ran K, Tamar G, Shmuell F, Eli A. Prevalence of significant non-cardiac findings on coronary multidetector computed tomography angiography in asymptomatic patients. *J Comput Assist Tomogr* 2007; **31**: 1–4. doi: <http://dx.doi.org/10.1097/01.rct.0000233125.83184.33>
 21. Wu W, Budovec J, Foley WD. Prospective and retrospective ECG gating for thoracic CT angiography: a comparative study. *AJR Am J Roentgenol* 2009; **193**: 955–63. doi: <http://dx.doi.org/10.2214/AJR.08.2158>
 22. Schindera ST, Graca P, Patak MA, Abderhalden S, von Allmen G, Vock P, et al. Thoraco-abdominal-aortoiliac multidetector-row CT angiography at 80 and 100 kVp: assessment of image quality and radiation dose. *Invest Radiol* 2009; **44**: 650–55. doi: <http://dx.doi.org/10.1097/RLI.0b013e3181acaf8a>
 23. Awai K, Takada K, Onishi H, Hori S. Aortic and hepatic enhancement and tumour-to-liver contrast: analysis of the effect of different concentrations of contrast material at multi-detector row helical CT. *Radiology* 2002; **224**: 757–63. doi: <http://dx.doi.org/10.1148/radiol.2243011188>