Extravascular incidental findings at multislice CT angiography of the abdominal aorta and lower extremity arteries: a retrospective review study

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Abstract

Purpose: To assess the frequency and clinical impact of extravascular incidental findings on routine CT angiography of abdominal aorta or lower extremity arteries.
Materials and methods: From January 2002 to July 2004, a total of 692 patients underwent CT angiography of abdominal aorta and lower extremity arteries. Two radiologists retrospectively reviewed by consensus cross-sectional images for the presence and clinical impact definition of extravascular findings. The revision of hospital charts, medical records, and all procedures' reports performed before and after CT angiography represented the standard of reference (SOR).
Results: Only 373 out of 605 patients in whom extravascular findings were found had a SOR; in these patients CT angiography obtained a true-positive incidental rate of 98.9% (369/373). For the clinical impact definition of CT-angiography incidental findings, a concordance with SOR was obtained in 56.3% of patients, whereas a subsequent investigation was required in 183 patients (183/369, 49.6%). Among clinically relevant incidental findings, a total of 35 malignancies (35/894, 3.9%) were detected in 20 patients (20/423, 4.7%); in 15 patients (15/423, 3.5%) malignancy was unknown before CT-angiography exam.
Conclusions: A careful observation of cross-sectional images, even if "time consuming", is mandatory not only to assess vascular findings but also to avoid a misdiagnosis of clinical relevant extravascular findings.

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Multidetector-row CT (MDCT) angiography represents today the reference point in the study of the abdominal aorta and an accurate and feasible imaging modality for the assessment of peripheral vascular occlusive disease [1–8]. With the rapid growth in the number of CT scans performed and with the introduction of multidetector scanners that allow the use of thinner collimation, extravascular incidental findings, which are defined as findings that appear unrelated to the original purpose of the scan, are being encountered. These incidental findings may raise concern about serious illness, generate additional diagnostic tests, and lead to therapeutic interventions with the potential benefits of early detection of serious asymptomatic conditions (such as cancer). Disadvantages include the increase of economic and psychological costs to the patients and the need for vascular radiologists to interpret enormous quantities of native cross-sectional images. Different authors evaluated the prevalence of incidental findings in patients undergoing abdominal pelvic CT for suspected colorectal carcinoma (CT-colonography) [9–16] or for suspected ureteric colic or renal stones (CT-urography) [17, 18] but, to the best of our knowledge, there has been no published work regarding the evaluation of extravascular incidental findings on CT angiography. The aim of this retrospective study was to evaluate the frequency and clinical importance of extravascular incidental findings on routine CT angiography of abdominal aorta or lower extremity arteries.

Materials and methods

Population

In order to identify patients who had undergone CT angiography of the abdominal aorta and/or lower extremity arteries, all CT examinations, performed between January 2002 and July 2004, were reviewed from our computerized database.

A total of 692 patients were enrolled (459 men and 233 women, with a mean age of 69.7 ± 13.9 (SD) years, range 48–92 years old). Four hundred and forty patients underwent CT angiography of abdominal aorta and 252 patients underwent CT angiography of lower extremity arteries for suspected stenoobstructive/dilatative disease.

For all CT examinations, a written informed consent was obtained.

CT technique

CT scans were acquired on a four-channel multidetector row CT system (Somatom Plus Volume Zoom; Siemens Medical Systems, Forcheim, Germany). In all patients unenhanced CT images were obtained from the level of the diaphragm to the symphysis pubis with 4×2.5 mm^2 slice collimation, a pitch of 6, 5 mm slice width and reconstruction interval, a table speed of 15-mm/rotation, and a 0.5 s gantry rotation time.

For the abdominal aorta, contrast-enhanced images were performed from suprarenal abdominal aorta to the common femoral artery with 4×1 mm^2 collimation, a pitch of 6, 1.25 mm slice width and 1 mm reconstruction interval, a table speed of 15-mm/rotation, and 0.5 s rotation time.

For lower extremity arteries, CT angiography was performed from suprarenal abdominal aorta to the feet with 4×2.5 mm^2 collimation, a pitch of 6, 3 mm slice width and 1.5 mm reconstruction interval, a table speed of 15-mm/rotation, and 0.5 s rotation time.

For abdominal aorta, a total of 421–545 reconstructed images per patient were obtained (mean 472.4 ± 21.7) whereas for lower extremity arteries a total of 669–864 images per patient (mean 773.1 ± 44.3) were reconstructed. The average time necessary to evaluate images in order to detect abdominal extravascular incidental findings was 12.7 min (range 10–14 min) and 10.8 min (range 8–12 min) for abdominal aorta and lower extremity arteries, respectively.

In all patients, 120 mL of iodinate nonionic contrast medium (Iomeprol 300 mgI/mL, Iomeron; Bracco, Milan, Italy) was injected into the brachial vein with a power injector at a flow rate of 3 mL/s. Scan delay was individualized per patient, using Siemens's proprietary bolus-tracking software (C.A.R.E. Bolus), to capture 100 HU on the abdominal aorta, at the level of the celiac trunk, to trigger scanning and ensure a correct peak enhancement.

Image analysis

All cross-sectional images were reviewed retrospectively by two experienced abdominal radiologists (A.F.; F.D.F.; > 5 years of experiences) by consensus at a dedicated workstation (Leonardo; Siemens Medical Systems), in a blinded-end fashion. Patients were confidentially protected (during the review, names, ages, identification numbers of patients, and imaging parameters were always hidden).

Axial CT scans were assessed for the presence of extravascular findings by means of a patient-by-patient analysis, using the following four-point confidence scale: score 0 for certainly absent, score 1 for indeterminate/doubtful findings, score 2 for probably present, and score 3 for certainly present. Before evaluating images, the readers were informed that a confidence level of 2 also represented a positive diagnosis of incidental findings.

In case of score 2 or 3, the readers were asked to define each finding (by means of a lesion-by-lesion analysis), according to the impact on the management and/or life expectation of the patient, as shown: type A (benign: of no or little clinical importance, unlikely to require any additional medical treatment), type B [indeterminate: requiring long-term follow-up (1 year at least)], type C (clinical relevant: requiring immediate medical or surgical attention), and type D (not assessable finding: requiring a subsequent investigation, such as laboratory testing, radiological imaging, endoscopy, biopsy).

Standard of reference

The study coordinator (R.I.), not involved in the evaluation, reviewed hospital charts, medical records, and all procedures' reports (laboratory testing, US, CT, MR, endoscopy, biopsy, surgical findings) performed before and after CT angiography to confirm or exclude incidental findings in patients who received a score of 2 or 3.

Data analysis

CT images evaluated with a score of 2 or 3 and confirmed as positive for incidental extravascular findings were considered as true-positive diagnoses, whereas false positive cases were represented by CT images with a score of 2 and 3, not confirmed at SOR. Patients with score of 0 and 1 were not included in the evaluation. For the definition of clinical impact, only incidental findings identified in patients who resulted true positive at SOR for the presence of extravascular findings were considered.

Results

On the basis of axial CT angiography images, incidental findings (score 0) were excluded in 75/692 patients (10.8%) and revealed in 617/692 (89.2%). A score of 2 or 3 was

Fig. 1.   CT angiography of abdominal aorta: axial-image. In a 58-year-old woman who underwent CT angiography for suspected abdominal aortic aneurysm, a mesenteric mass (arrow) was also detected, requiring surgical attention.

assigned to 26/617 (4.2%) and 579/617 (93.9%) patients, respectively, for a total of 605/617 patients (98.1%), whereas in the last 12 patients (1.9%) CT exam was considered indeterminate or doubtful (score 1) (Figs. 1–6).

However, only 373 out of 605 patients with a score of 2 or 3 (61.7%) had a standard of reference (SOR) to confirm or exclude CT-angiography results. In 369 out of 373 (98.9%) patients, SOR revealed the presence of incidental findings with only 4/373 false positive CT-angiography diagnoses (1.1%). A total of 894 incidental findings were found in 369 true positive patients. These findings were classified, according to the impact on the management and/or life expectation of the patient, as follows: 482/894 (53.9%) type A, 36/894 (4%) type B, and 24/894 (2.7%) type C (Figs. 1–4). The last 352/894 (39.4%) lesions, detected in 183 patients (183/369, 49.6%), were considered type D (not assessable), requiring a subsequent investigation.

The SOR confirmed all 894 incidental findings and allowed to classify 802/894 (89.7%) as benign which included in 480 out of 482 incidental findings classified as type A (benign on CT), 35 out of 36 as type B (Fig. 5); 1 out of 24 as type C, and 286 out of 352 incidental findings as type D (Table 1). At SOR 92/894 (10.3%) incidental findings resulted clinically relevant (Table 2): these included 2 out of 482 type A (benign), 1 out of 36 type B (indeterminate) (Fig. 6); 23 out of 24 type C (clinical relevant), and in 66 out of 352 type D (not assessable). Among clinically relevant incidental findings, a total of 35 malignancies (35/894, 3.9%) were detected in 20 patients (20/369, 4.7%); in 15 patients (15/423, 3.5%) malignancy was unknown before CT angiography and resulted to be N0M0 at surgery.

Fig. 2.   CT angiography of lower extremities: axial-image. 69-year-old man. CT angiography, performed for diffuse dilatative and steno-obstructive disease, allowed also to detect an unknown pulmonary malignancy (arrow), as confirmed at surgery.

Fig. 3.   CT angiography of abdominal aorta: axial-image. 68-year-old man. CT exam confirmed the presence of an abdominal aortic aneurysm and also detected an unknown asymptomatic cystic renal cell carcinoma (arrow), as confirmed at surgery.

By comparing SOR with readers results concerning the definition of incidental findings, we found a concordance in 503/894 (56.3%), including 480 benign and 23 classified as clinically relevant.

Discussion

Our study showed that one of the intriguing features of CT angiography of abdominal aorta or lower

Fig. 4. CT angiography of abdominal aorta: axial-image. 73-year-old man. CT angiography, performed for abdominal aortic aneurysm, allowed also to detect a colon cancer (*arrows*), requiring surgical treatment.

Fig. 5. CT angiography of abdominal aorta: axial-image. 78-year-old man. CT angiography detected indeterminate incidental findings represented by an adrenal mass (*arrow*), needing long-term follow-up.
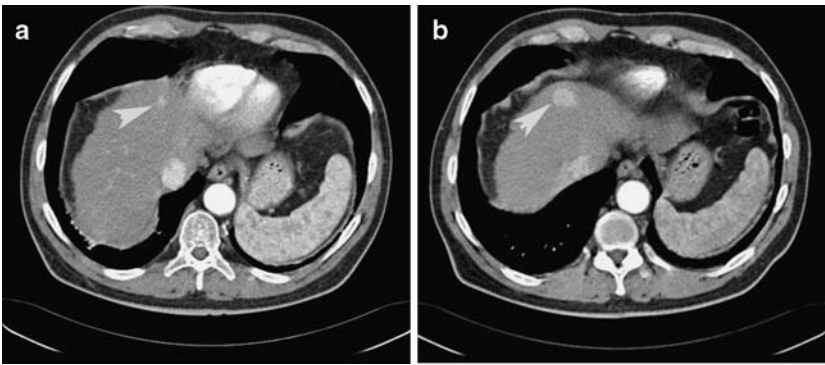

Fig. 6. CT angiography of lower extremity: axial-images (**A, B**). 62-year-old woman. CT angiography, performed for peripheral steno-obstructive disease, detected a hypervascular unknown asymptomatic indeterminate focal liver lesion (**A**, *arrow*), requiring long-term follow-up. At 6-month multiphasic CT follow-up, liver lesion increased in size (**B**, *arrow*) and a diagnosis of hepatocarcinoma was carried out, confirmed at surgery.

extremity arteries is its ability to detect extravascular lesions, referred to as "incidental findings", because the whole abdomen, pelvis, and lower lung fields are imaged, as opposed to just the aorta and its branches. In our series, 617/692 (89.2%) patients were classified as having extravascular lesions and, when considering only lesions for which SOR was available, the number of patients was 369/605 (61%). These findings have been classified according to their clinical importance: 23 out of 24 lesions judged as clinically relevant, that is requiring immediate medical or surgical attention, were confirmed by SOR. Furthermore, at SOR 2 findings classified as benign, 1 classified as indeterminate (requiring follow-up), and 66 classified as not assessable (requiring a subsequent different investigation, such as radiological imaging, endoscopy, biopsy, etc.) resulted to be clinically relevant, for a total of 92/894 (10.3%) significant findings.

Different authors evaluated the prevalence of incidental findings in patients undergoing abdominal-pelvic CT for suspected colorectal carcinoma (CT colonogra-phy) or for suspected ureteric colic or renal stones (CT urography): in these series, the incidence of "significant" incidental findings was variable between 4% and 17% [9–18].

When considering the rate of malignancy, our results showed higher values (4.7% of the patients) than those reported in the other studies (≤ 2%) [10, 11, 14, 16]. The high incidence of malignancies in our study could be mainly explained by the i.v. administration of the contrast medium during CT angiography, not required in CT colonography and CT urography. The use of contrast medium has the added advantage of facilitating the evaluation of extravascular tissues, which reasonably reduces the need for follow-up examination and allows the characterization of questionable parenchymal lesions. The influence of age may be considered as a further important aspect of our different rate of incidental findings: with an aging population, represented by patients with vascular disease, an increasing number of incidental findings is likely to be detected [10]. On the other hand, the decrease in collimation generally results

Table 1. Benign extravascular incidental findings detected at axial CT angiography images and confirmed by SOR

Renal cysts	243
Renal calcifications/stones	23
Focal renal parenchymal reduction	18
Benign renal mass (hemorrhagic, hyperdense)	21
Benign adrenal mass	27
Hepatic cysts	151
Benign hepatic mass	18
Gallstone/significant biliary calcification	33
Biliary dilatation (not requiring treatment)	4
Benign lung nodules	73
Pleural plaque	13
Pulmonary emphysematous bullae	16
Pleural fluid (not requiring treatment)	12
Benign splenic mass	11
Pancreatic cysts	9
Pancreatic calcifications/focal chronic pancreatitis	3
Benign uterine mass/uterine enlargement/calcifications	25
Ovarian cysts	29
Bladder diverticulum	4
Benign abdominal/retroperitoneal mass	1
Pelvic fluid collection (not requiring treatment)	11
Diverticular	27
Benign muscular lesions (lipoma)	3
Benign focal bone lesions	18
Inguinal/abdominal wall hernia	4
Hiatal hernia	2
Esophageal varices	3
Total	802

Table 2. Clinical relevant extravascular incidental findings detected at axial CT angiography images and confirmed by SOR

Ureteral stones	7
Moderate/severe hydronephrosis	9
Malignant renal mass	5
Malignant adrenal lesions	1
Biliary dilatation	8
Cholecystitis	2
Malignant hepatic mass (cholangiocarcinoma, HCC, metastases)	10
Pleural fluid	8
Malignant pulmonary opacity	4
Pancreatitis	2
Malignant pancreatic mass	3
Malignant uterine mass	2
Malignant ovarian mass	1
Bladder tumor	3
Malignant abdominal/intra-retroperitoneal mass	1
Bowel obstruction	6
Diverticulitis	2
Bowel thickening (malignant lesion)	2
Pelvic fluid collection	7
Malignant ascites	6
Lymphadenopathy (lymphoproliferative disease)	2
Malignant bone lesions	1
Total	92

in increased image noise and, therefore, was thought to have a negligible effect in improving the detection of extravascular findings.

As reported in the literature [10, 16], our data showed that, although many lesions were deemed important, in terms of the need for investigation, the incidence of serious disease detected was considerably lower. In our study, notwithstanding the use of contrast medium, additional investigations were required in 49.6% of pa-

tients in order to characterize the nature of the incidental findings. This relatively high rate could be due to the lack of a dynamic contrast-enhancement CT study that allows an accurate tissue characterization. As a matter of fact, during CT angiography only the arterial phase is routinely acquired after contrast injection.

Moreover, our experience confirmed that the majority of extravascular lesions that undergo further work-up or require long-term follow-up turn out to be benign. It is possible that the rate of incidental findings which resulted to be benign at further investigation or follow-up may have a substantial impact on the utility of detecting these lesions, contributing to heath care costs and patient anxiety. Furthermore, some of these investigations may be invasive (i.e., endoscopy, biopsy) and carry their own morbidity (X-ray exposure).

However, an early cancer detection in 15/369 (4%) patients is significant in clinical terms. The detection of lesion at this stage is, of course, most likely to result in health gain, reducing costs, and hospital courses owing to less complicated surgical procedures.

This aspect justifies that a careful observation of true cross-sectional images is mandatory not only to assess vascular diseases [7] but also to avoid a misdiagnosis of clinical relevant extravascular findings. Undoubtedly, the accurate visualization of complete axial images dataset is a significant "time-consuming" phase and the availability of appropriate software to perform the semiautomatic/automatic editing could represent an advantage for time saving in processing CT-angiography reports. Nevertheless, the only use of CT-angiography images obtained by means of automatic editing, without the evaluation of native axial images, could compromise extravascular incidental findings detection.

A limitation of our study is that it was not possible to have confirmation, or otherwise, of all patients enrolled in our study. In fact, only 373/605 patients with a score of 2 or 3 (61.7%) had a SOR and were considered in the evaluation. Possible reasons for this include the fact that the suggested investigations might have been undertaken outside our institution, and the reluctance of patients to undergo further investigation, due to the cost and invasiveness of some procedures, or to patient unselfishness or indifference.

Another potential limitation could be the lack of routine CT angiography false-negative rate, which indicates how many extravascular findings were missed by radiologists at the time of CT reporting. This potential purpose is beyond the scope of our study.

In conclusion, our work suggests that a careful observation of cross-sectional images, even if "time consuming", is mandatory not only to assess vascular findings but also to identify extravascular incidental findings that would otherwise be diagnosed late, changing the prognosis, management, and outcome of patients.

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