Multi-Detector CT Scanner Angiography for Initial Evaluation of Neck Injuries

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Abstract

Aim of Study: To assess the diagnostic validity of multi-detector CT (MDCT) angiography.

Patients and Methods: We evaluated MDCT angiography in 57 patients (40 males and 17 females, mean age, 33.6 ± 14.5 years; age range, 16-63 years), who were referred to the Radiology Department with trauma to the neck. They were hemodynamically stable. Diagnostic quality was scored as either "diagnostic", depending upon detection of enhanced blood vessels clearly, no artifacts and good background tissue. "Nondiagnostic" if blood vessels were unclear and/or presence of marked artifacts. It is also considered diagnostic when the common carotid artery, internal carotid artery, aortic arch branches as well as the vertebral arteries in both sides were readable. Patient outcome after admission to the hospital was used as the standard of reference for comparison with results of MDCT angiography.

Results: Two patients (3.5%) were "nondiagnostic". Examinations for the remaining 55 patients (96.5%) were "diagnostic". A total of 440 arteries were evaluated with MDCT angiography. Vascular injuries were present in 15 patients (27.3%), while the arteries were normal in 40 patients (72.7%). The details of injuries were relative unilateral stenosis of one vertebral artery (7, 12.7%), relative stenosis of one common carotid artery (4, 7.3%), incomplete common carotid thrombosis (2, 3.6%), common carotid pseudoaneurysm (1, 1.8%), partial occlusion of internal carotid artery (1, 1.8%). The specificity of MDCT in cases with neck injuries was 95.2%, the sensitivity was 100%, positive predictive value was 88.2%, negative predictive value was 100%, while diagnostic accuracy was 96.5%.

Conclusions: MDCT angiography is a good alternative to conventional angiography for patients who are hemodynamically stable. It is a rapid, accurate, noninvasive technique and is less expensive than conventional angiography.

Recommendation: The high validity is an additional reason to prefer this low-risk, noninvasive and reproducible method as an initial diagnostic examination in these patients.

Key Words: Multi-detector CT scanner – Angiography – Neck injuries.

Introduction

PHYSICAL examination alone has low sensitivity for detection of vascular injuries in patients suspected of having arterial injuries without compromise of their vital signs. Several strategies for diagnosis and management may be considered [1].

Conventional angiography is a relatively safe, yet invasive procedure with reported incidence of complications of 0.16%-2.0%, which include [2] hematomas at the puncture site, vascular spasms, thrombosis, distal embolization of atheromatous plaques and thrombus and vascular dissection. Moreover, complications involving the central nervous system can be catastrophic and potentially result in permanent damage. Hence, angiography in patients in stable condition with neck trauma has been questioned because of the reported complications [3,4].

Color Doppler ultrasonography (US) is inexpensive and completely noninvasive, which does not require administration of contrast medium. For the diagnosis of traumatic vascular injuries, it [5,6,7] has been proposed as a noninvasive test. It can give adequate information about flow, lumen, vascular wall and thrombus features [7]. However, it is operator dependent and may take a long time, even in skilled hands, which is not desirable in patients in potentially unstable condition [7,8].

Magnetic resonance (MR) imaging has been also described for evaluation of potential vascular injuries [9], as these lesions may arise clinically, with late manifestation and neurologic deterioration due to bleeding and embolism or ischemia. However, MR angiography is time consuming and the support equipment may not be compatible with the magnet [10].
Very recently, multi-detector CT (MDCT) has gained wide acceptance in the evaluation of traumatic and nontraumatic emergency conditions [11]. High-quality diagnostic images are obtained in a short time. MDCT angiography has also been used to plan large facial and neck reconstructions in trauma and oncology because it allows correct assessment of the vascular anatomy and the evaluation of blunt traumatic dissection [12]. It is a non-operator-dependent diagnostic study and results can be easily reproducible in any trauma center by using established technical parameters. It offers less discomfort for the patient and decreases costs [10].

MDCT is gradually replacing the traditional imaging techniques such as conventional radiography, conventional contrast material-enhanced studies and conventional angiography. However, the experience of using MDCT scanner angiography for the initial evaluation of neck injuries remains to be assessed.

Aim of study:
The purpose of this study was to report our experience with MDCT scanners as the initial procedure to rule out arterial lesions caused by neck injuries and to assess its diagnostic validity.

Material and Methods
Setting:
This study was conducted prospectively for 12 months (from January 2004 to December 2004) in Buraidah central hospital, Al-Qassim, Kingdom of Saudi Arabia.

Patients:
We evaluated MDCT angiography as an initial diagnostic procedure in 57 patients (40 males and 17 females, mean age, 33.6 ± 14.5 years, age range, 16-63 years), who were referred to the Radiology Department with trauma to the neck. They were hemodynamically stable. Patients with diminished pulses, bruit, or thrill over the wound, nonexpanding hematoma, or nonpulsatile bleeding were candidates for MDCT angiography. Moreover, the study included those referred to the Radiology Department after any surgical vertebral procedures and other postoperative neck procedures.

Patients with arterial abnormalities demonstrat ed at MDCT angiography were referred for conventional arteriography for endovascular therapy or were sent directly to surgery.

Conventional arteriography was performed for diagnosis in subjects who were initially admitted for observation after negative MDCT arteriographic results but who later developed signs or symptoms of a potential arterial injury. Conventional arteriography was performed only for patients whose MDCT angiographic studies were considered non-diagnostic.

Informed consent was obtained from either the patients themselves or from a close relative when the patient was unable to give consent.

Exclusion criteria:
Patients who had definite signs of arterial injuries or those who were hemodynamically unstable with obvious vascular injury were directly taken to surgery with no need for further imaging procedures [13]. All patients with cervical injuries were immediately transported for surgical exploration if they were hemodynamically unstable or if they had an expanding hematoma, pulsatile bleeding, neurologic deficit, or air bubbling in the wound.

MDCT angiography:
MDCT angiography was performed using a 16-MDCT scanner (Somatom Sensation 16, Siemens Medical Solutions). Images were reconstructed at an effective slice thickness of 1mm and a reconstruction interval of 1.2mm was used. The delay between the start of contrast medium administration and the start of scanning was determined individually for each patient using standard bolus-tracking software (Care Bolus, Siemens). Contrast medium and saline solution were each injected monophasically at a rate of 4mL/s.

The CT examination started at the base of the skull and extends to the aortic arch. Exposure time is about 20sec. Abnormalities were determined as being absent (normal examination results) or present (abnormal examination results). Arterial abnormalities were classified as follows: Partial thrombosis or complete obstruction (occlusion), pseudoaneurysm (extravascular collection of contrast medium), arteriovenous fistula (early filling of venous structures) and intimal flap (intraluminal linear filling defect). Finally, the researcher reported any associated nonvascular abnormalities (if present) such as fractures, soft-tissue hematoma, airway injuries and spinal cord lesions. Peripheral branches of the proximal external carotid arteries were not evaluated because of the limitations in spatial resolution of MDCT angiography, as compared with the limitations at conventional angiography.

Image reconstruction and review:
CTA data sets were reconstructed and analyzed using a workstation (Leonardo, software version
VB30A, Siemens). Maximum-intensity-projection (MIP) reconstructions were produced by one operator after semiautomated bone removal. Bone removal was performed using the 3D function of the workstation. Axial slices were carefully reviewed to ensure that no vascular structures were included in the bone volume, which was subsequently subtracted. MIP reconstructions were performed and displayed in many oblique projections to make the best use of the image matrix and thus optimize spatial resolution.

Diagnostic quality was scored as either "diagnostic", depending upon detection of enhanced blood vessels clearly, no artifacts and good background tissue. "Nondiagnostic" if blood vessels were unclear and/or the presence of marked artifacts. It is also considered diagnostic when the common carotid artery, internal carotid artery, aortic arch branches as well as the vertebral arteries in both sides were readable.

Patients' follow-up:

Patient outcome after admission to the hospital was used as the standard of reference for comparison with results of MDCT angiography. Patients with normal MDCT angiographic results were admitted for observation and discharged 12-24 hours later, if their clinical status remained stable. After discharge, these patients were followed-up clinically with weekly physical examinations and interviews for 4 weeks and then with monthly telephone interviews for 6 months. These examinations and telephone contracts were conducted by the researcher. For patients who remained asymptomatic after clinical follow-up, we assumed that no arterial damage had been caused by the injury and that negative MDCT angiographic interpretations were true-negative results.

Statistical analysis:
The diagnostic validity of MDCT (i.e., sensitivity, specificity, positive and negative predictive values and diagnostic accuracy) was calculated according to Spitalnic [14], as follows:

\[
\text{Sensitivity} = \frac{\text{True positive}}{\text{True positive} + \text{False negative}} \times 100
\]

\[
\text{Specificity} = \frac{\text{True negative}}{\text{True negative} + \text{False positive}} \times 100
\]

\[
\text{Positive predictive value} = \frac{\text{True positive}}{\text{True positive} + \text{False positive}} \times 100
\]

\[
\text{Negative predictive value} = \frac{\text{True negative}}{\text{True negative} + \text{False negative}} \times 100
\]

Diagnostic accuracy = True positive + True negative \over All cases \times 100

Cases with "nondiagnostic" finding was considered an indication to perform conventional angiography. Hence, these cases were considered as false-positive interpretations.

Results

Transverse MDCT images were sufficient to furnish the proper diagnosis in most cases of neck injuries. However, reformatted and 3-D images are complementary in complex cases. MDCT angiographic studies revealed that 2 patients (3.5%) were "nondiagnostic" because of multiple artifacts arising from bullet fragments in one case and internal fixation of cervical spine in another case. However, conventional arteriography in these patients revealed normal findings. These two cases were considered as false positive.

Examinations for the remaining 55 patients (96.5%) were "diagnostic". A total of 440 arteries (330 carotid arteries, including the common, internal and proximal external carotid arteries and 110 vertebral arteries) were evaluated with MDCT angiography.

Vascular injuries were present in 15 patients (27.3%), while the arteries were normal in 40 patients (72.7%). The details of injuries were relative unilateral stenosis of one vertebral artery (7, 12.7%), relative stenosis of one common carotid artery (4, 7.3%), incomplete common carotid thrombosis (2, 3.6%), common carotid pseudoaneurysm (1, 1.8%, Fig. 1), partial occlusion of internal carotid artery (1, 1.8%), as shown in Table 1.

<table>
<thead>
<tr>
<th>Angiographic findings</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-diagnostic</td>
<td>2</td>
<td>3.5</td>
</tr>
<tr>
<td>Diagnostic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No vascular injury (normal)</td>
<td>55</td>
<td>96.5</td>
</tr>
<tr>
<td>Vascular injuries:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Relative unilateral stenosis of one vertebral artery</td>
<td>7</td>
<td>12.7</td>
</tr>
<tr>
<td>• Relative stenosis of one common carotid artery</td>
<td>4</td>
<td>7.3</td>
</tr>
<tr>
<td>• Incomplete common carotid thrombosis</td>
<td>2</td>
<td>3.6</td>
</tr>
<tr>
<td>• Common carotid pseudoaneurysm</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>• Partial occlusion of internal carotid artery</td>
<td>1</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Table 1: MDCT angiographic finding.
All patients were followed for one month. Patients with no vascular injury (n=40) remained asymptomatic for the whole follow-up period (true negative). Patients with vascular injuries (n=15) were sent to the vascular surgery department for management. Accordingly, the specificity of MDCT in cases with neck injuries was 95.2%, the sensitivity was 100%, positive predictive value was 88.2%, negative predictive value was 100%, while diagnostic accuracy was 96.5%, as shown in Table (2).

Table (2): Diagnostic validity of MDCT in cases with neck injuries.

<table>
<thead>
<tr>
<th>Result of MR imaging</th>
<th>Vascular injury</th>
<th>No vascular injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>15</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>42</td>
<td>57</td>
</tr>
</tbody>
</table>

Sensitivity: 15/15 = 100%
Specificity: 40/42 = 95.2%
Diagnostic accuracy: 55/57 = 96.5%
Positive predictive value: 15/17 = 88.2%
Negative predictive value: 40/40 = 100%

Differences in results reported by different studies in different localities may reflect the differential extent of violence or severity of trauma in different communities. In addition, this is also dependent on the criteria for physician’s decision to refer a patient to the Radiology Department for MDCT angiography, whether he refers all cases of neck trauma, even with minor trauma or only those with high suspicion of vascular injury.

Fig. (1): Right common carotid arterial pseudoaneurysms with extravascular collections of contrast material. A small intimal flap is seen within the arterial lumen. There is enlargement of the adjacent soft tissues because of swelling and hematoma. A 3-D shaded-surface display image demonstrates the extravascular collections of contrast material.

Discussion

The present study showed that vascular injuries were diagnosed in more than one-fourth of cases with neck trauma (15 out of 55, 27.3%). This finding is relatively higher than that reported by other studies. Demetriades et al. [18] noted that vascular injuries occur in 18%-30% of cases with neck trauma. However, Munera et al. [10] reported vascular injuries only in 15.6% of their cases of neck injuries.

Results of the present study showed that cases who were interpreted as normal, there was no further complication during follow-up and these patients did not require further treatment or diagnostic studies. In addition, the limitations of MDCT angiography included the presence of some artifacts in two cases. These artifacts obscure arterial segments. In these two cases, MDCT angiographic results were considered as "nondiagnostic" and patients underwent conventional angiography. Hence, the diagnostic validity of MDCT, with 100% sensitivity and negative predictive value, a specificity of 95.2% and a positive predictive value of 88.2%. The overall diagnostic accuracy was 96.5.

In conclusion, MDCT angiography is a good alternative to conventional angiography for patients who are hemodynamically stable. It is a rapid, accurate, noninvasive technique and is less expensive than conventional angiography. The high validity is an additional reason to prefer this low-risk, noninvasive and reproducible method as an initial diagnostic examination in these patients.

References


