Percutaneous abdominopelvic interventional procedures using real-time CT fluoroscopy guidance at 21 mA: an analysis of 99 consecutive cases

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Purpose. The purpose of our study was to retrospectively evaluate the efficacy, the limitations and the complications of real-time CT fluoroscopy (Carevision) as an adjunct to CT guidance for percutaneous abdominopelvic interventional procedures.

Materials and methods. During a 28 month period, 99 patients (55 men, 44 women) with a mean age of 59 years had percutaneous abdominopelvic interventional procedure under CT guidance using CT fluoroscopy. Sixty-four patients had a percutaneous drainage of an abdominopelvic fluid collection with a Seldinger technique using an 8.5- to 14-F drainage catheter and 35 patients had a percutaneous biopsy using an 18-G automatic core biopsy needle.

Results. In all cases, the quality of the real-time CT fluoroscopic images allowed to securely monitor needle advancement towards the target lesion and to confirm correct position of the needle tip. The diameters of target lesions ranged from 1.5 to 10 cm, with a mean value of 4.75 cm. No immediate complications were observed. The real-time CT fluoroscopy times ranged from 25 to 242 sec, with a mean time of 117 sec. All percutaneous procedures (100%) were successfully performed.

Conclusion. Our initial clinical experience suggests that real-time CT fluoroscopy allows to perform effective and secure percutaneous abdominopelvic interventional procedures. However, because of substantial radiation exposure, its use has to be limited to specific and selected cases.

Keywords: CT-fluoroscopy. Percutaneous drainage. Percutaneous biopsy.
ileocolic anastomosis). Some CT guidance procedures are therefore sometimes risky (1, 2). The development of a real-time CT fluoroscopy technique, as first described by Katada et al. (3), has overcome these drawbacks. Real-time CT (RT-CT) fluoroscopy is now used by many teams for guidance of some interventional procedures. Conceptually, the RT-CT fluoroscopy technique combines the advantages of helicoidal CT with fluoroscopic real-time imaging (1-3).

Our retrospective study was designed to analyse the efficacy, limitations and complications of low current (21 mA) RT-CT fluoroscopy guidance and to determine the time required for routine use of this technique to guide percutaneous abdominopelvic interventional procedures.

Materials and methods

Patients

Over a 28 month period (March 2003 to July 2005), all CT-guided percutaneous abdominopelvic interventional procedures were carried out using an RT-CT fluoroscopy system. Ninety-nine consecutive patients (55 men, 44 women), ranging in age from 18 to 90 years old (mean = 59 years old), benefited from this procedure in our service.

Equipment

All procedures were carried out using a third generation CT scanner (Somatom Plus 4 Volume Zoom, Siemens Medical Systems, Erlangen, Germany) managed with the CARE Vision CT software package (Combined Applications to Reduce Exposure) and RT-CT fluoroscopy. The image acquisition parameters were as follows: kilovoltage=120 kV, amperage =21 mA, collimation=10 mm (±2.5 mm), with a tube rotation velocity of 0.5 s/360° sweep. The entrance skin dose recommended by the manufacturer was 3.36mSv/s for RT-CT fluorometry, or a cumulated dose of 201 mSv/min of RT-CT fluorometry for the concerned slices. The RT-CT fluorometry images were calculated at a rate of 8 images/s with a 256x256 reduced matrix, reconstruction and 0.3 s lag, and with a 1024x1024 matrix on the CT display console facing the operator beside the stand in the CT scanning room. A joystick attached to the scanner table controlled its longitudinal movement. A laser beam was used to localize the CT reference slice. The RT-CT fluorometry procedure was initiated via a mobile operator-controlled pedal. During the procedures, the operator was stationed in front of the stand, alongside the patient lying prone on the table. The operator wore a lead apron and a thyroid protector in all cases.

Procedures

For all of these procedures, a laser marker was used to pinpoint the skin entry slice and the entry point was localized with a metallic element in incremental CT mode. The initial puncture was then performed by holding the needle with metallic, 25 cm long, right surgical dressing forceps (Braun-Aesculap) – the operator could thus hold the needle without risk of hand exposure to the X-ray beam. RT-CT fluorometry was used intermittently to ensure precise advancement of the needle towards the target. When the needle point was no longer in the initial axial RT-CT fluorometry plane, the operator adjusted the table movements to retarget the needle.

Details on the different procedures are given in table I. Forty-nine drainages were performed immediately following a diagnostic CT scan, during the same session, while the patient was still on the CT table. Nine drainages (9/64; 14%) were performed through a posterior translateral approach, which seemed the most secure because the abscess could not be safely drained using an anterior percutaneous approach due to interposition of the small intestine, part of the colon or bladder. Moreover, a lateral approach could not be implemented because of the presence of iliac vessels or the small intestine along the pelvic wall. All drainages were performed under local anaesthesia with subcutaneous and deep-layer injection of 10 ml lidocaine hydrochloride (Xylocaine 1%, AstraZeneca, Rueil-Malmaison, France). When possible, i.e. for programmed procedures, patients received 50 mg hydroxyzine (Atarax®, UCB Pharma SA, Nanterre, France) and 2 g paracetamol (Dafalgan®, Laboratoires UPSA, Paris-La Défense, France) orally 1 hour prior to drainage. Patients were also administered a broad-spectrum antibiotic that was initially selected empirically and then, when necessary, adjusted to the antibiogram. After selecting the safest and simplest approach on the CT images, the abscess was initially punctured with an 18- or 19-gauge 15 cm long catheter needle (Ingecath®, CathNet Science, Paris, France, or InterV, Medical Device Technologies, Gainesville, FL, USA). The aspirates were sent to a bacteriology laboratory for direct testing (Gram staining), aerobic and anaerobic culture, and also to a biochemical laboratory for analysis. After checking that the point of the catheter needle was correctly positioned at the abscess core by RT-CT fluorometry, a j-shaped teflon-coated guidewire was coiled in the catheter and inserted in the abscess using the conventional Seldinger technique. Following dilation with a rigid hydrophilic dilator until the chosen drain size was reached, the drain was installed in the abscess cavity, attached to the skin with two stitches and connected to a vacuum wound drainage system (Drainobag®, Lock 600, Braun). A 8.5 to 14-F drainage catheter with a curved hydrophilic tip (Flexima®, Boston Scientific, Natick, MA, USA) or a looped tip (Hydrofeel®, PBN Medicals, Stenlose, Danemark) was used for the 64 drainages.

Thirty-five biopsies were performed after local anaesthesia and oral premedication according to the same procedure as that used for drainage. The biopsy specimens were fixed in Bouin’s solution and sent to a pathology laboratory. An additional specimen was obtained for culture and polymerase chain reaction (PCR) analysis of DNA when tuberculosis involvement was suspected. All biopsies were performed with an 18-gauge automatic core biopsy needle (Achieve™, Cardinal Health, McGaw Park, IL, USA) designed to collect 20 mm long biopsy specimens. A coaxial system was used when two different biopsies were required.

Table I

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
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<tbody>
<tr>
<td>Percutaneous biopsy</td>
<td>13</td>
</tr>
<tr>
<td>(n=35) Retroperitoneal adenomegaly</td>
<td>10</td>
</tr>
<tr>
<td>(n=13)</td>
<td>5</td>
</tr>
<tr>
<td>Adrenal gland mass</td>
<td>3</td>
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<tr>
<td>Pancreatic mass</td>
<td>2</td>
</tr>
<tr>
<td>Peritoneal mass</td>
<td>2</td>
</tr>
<tr>
<td>Hepatic nodule</td>
<td>3</td>
</tr>
<tr>
<td>Renal mass</td>
<td>8</td>
</tr>
<tr>
<td>Percutaneous drainage</td>
<td>4</td>
</tr>
<tr>
<td>(n=64) Abscess or post-op aspiration</td>
<td>10</td>
</tr>
<tr>
<td>Abscessed diverticular sigmoiditis</td>
<td>3</td>
</tr>
<tr>
<td>Abscessed psosas</td>
<td>8</td>
</tr>
<tr>
<td>Hepatic abscess</td>
<td>1</td>
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<tr>
<td>Crohn’s disease abscess</td>
<td>1</td>
</tr>
</tbody>
</table>
Data analysis

For all procedures, CT and RT-CT fluorometry images were analysed to evaluate the target size and aspiration needle imaging quality. The cumulated RT-CT fluorometry time was determined through an assessment of the intervention records.

Results

In all cases, the quality of the RT-CT fluorometry images enabled the operator to clearly monitor the needle advancement towards the target lesion and confirm the proper position of the needle tip. The mean target lesion diameter was 4.82 cm (range 1, 5-10 cm). The mean cumulated RT-CT fluorometry time for all procedures was 125 s (range 25-242 s). All procedures were successful (100%).

All abscess punctures and aspirations were performed successfully (fig. 1), thus enabling collection of liquid aspirate in which the analysis revealed the presence of pus in 55 patients (55/64; 86%), an infected hematoma in 5 patients (5/64; 8%) and a clear but infected liquid in 4 patients (4/64; 6%). No hemorrhagic complications were noted. The only complication occurred in one patient after drainage of an hepatic abscess, where the patient developed a severe infectious syndrome 4 h following drainage, but the outcome was favourable. The cumulated RT-CT fluorometry time for drainages ranged from 32 to 242 s (mean 148 s).

The needle biopsies were successful in all cases (100%) (fig. 2), with a single needle puncture required in 30 cases (30/35; 86%) and two punctures in 5 cases (5/35; 14%). These latter 5 cases concerned hypertrophic lymph nodes (n=3) or peritoneal masses (n=2) suspected to be associated with tuberculosis. No immediate complications were noted. The cumulated RT-CT fluorometry time for needle biopsies ranged from 25 to 147 s (mean 82 s).
Discussion

No clear evidence on the benefits of using RT-CT fluorometry for guidance of abdominopelvic interventional procedures has been reported to date – the published results are varied. Silverman et al. did not find a significant difference with respect to the success of the procedure for biopsy or drainage (4). Similarly, Carlson et al. obtained an identical success rate with or without fluoroscopy (5). We consider that RT-CT fluorometry cannot substantially improve the success rates already obtained for over 30 years (6) with procedures that are effectively managed by many teams, with up to 95% success reported in the literature (7). However, in our experience, the addition of RT-CT fluorometry may broaden the scope for drainage management and decision making. In our routine clinical activities, we almost always achieve a successful abdominopelvic needle aspiration with RT-CT fluorometry. This has also been confirmed by several authors (1-4) who have found that RT-CT fluorometry is highly beneficial for guiding procedures to treat target lesions located in the vicinity of mobile small intestines, or when irritated or tired patients cannot remain still throughout the procedure. The benefits of RT-CT fluorometry are further substantiated by the fact that needle biopsy and drainage times are significantly shortened by the use of RT-CT fluorometry in the study of Silverman (29 min with RT-CT fluorometry as compared to 36 min with standard CT guidance) (4), and confirmed by Froelich et al. (14.7 min with RT-CT fluorometry as compared to 21.8 min with standard CT guidance) (8). To our knowledge, only Spies et al. did not note a significant difference between the two intervention guidance techniques (9).

Finally, the findings of Froelich et al. (8) highlighted that the use of RT-CT fluorometry for guidance of percutaneous drainage procedures significantly reduced the number of needle puncture attempts, thus potentially lowering the complication risk and clearly enhancing patient comfort.

Various other RT-CT fluorometry indications in abdominal pathology interventions have been reported, e.g. for guidance of hepatic arterial chemoembolisation, but the effectiveness has not yet been clearly documented (10). RT-CT fluorometry facilitates imaging of Lipiodol® dissemination during chemoembolisation, thus improving analysis of its fixation on tumours. The benefits of this real-time data are, however, not yet clearly established. Laufer et al. consider that RT-CT fluorometry provides a clearer display of a needle trajectory than ultrasound and could therefore improve guidance of percutaneous placement of a biliary prosthesis (11), but the benefits of RT-CT fluorometry in this procedure have not been confirmed by other teams. In our experience, combining fluoroscopy and ultrasound enables real-time monitoring of catheter needle advancement in biliary ducts and determination (with high confidence) of whether a biliary duct has been entered. RT-CT fluorometry cannot, however, be used in some cases to guide percutaneous placement of a gastronomy tube, especially after gastric surgery or when there is colic interposition between the stomach and the abdominal wall, but RT-CT fluorometry seems to be very beneficial for ensuring the safety of this procedure (12).

No needle drainage or biopsy failures were noted in our study. Moreover, our results are in agreement with those published by some other authors, for instance Froelich et al. reported achieving 100% success with RT-CT fluorometry guidance of percutaneous drainage procedures (8), while Daly et al. obtained a 94% success rate in a series of 119 RT-CT fluorometry guided percutaneous abdominal and pelvic interventional procedures (2). However, these authors considered that the RT-CT fluorometry images were inadequate for imaging two hepatic lesions as the contrast was very low without contrast medium enhancement. This was the only reason for failure of the procedures (2). To overcome this contrast limitation, Kirchner et al. (13) proposed to combine RT-CT fluorometry with iv injection of iodinated contrast medium during needle biopsy. Their study involved patients presenting with hepatic lesions having the same attenuation as the adjacent parenchyma, so RT-CT fluorometry guided needle
biopsy was not possible due to the lack of target lesion visibility. In these cases, simultaneous iv injection of iodinated contrast medium clearly enhanced the target lesions, thus facilitating their biopsy. Lucey et al. proposed to increase the amperage when the lesions targeted for biopsy were not visible at 30 mA (14). Although these authors used standard CT rather than RT-CT fluorometry for guidance, these modifications in the imaging constants could also be considered for RT-CT fluorometry (15).

The mean RT-CT fluorometry time seemed relatively high in our study, but it was within the same range as the times reported by Daly et al. (2), i.e. a mean RT-CT fluorometry time of 133 s (range 35-336 s) for needle biopsies and 186 s (range 20-660 s) for drainages. However, other teams reported shorter RT-CT fluorometry times, e.g. Gianfelice et al. obtained a mean time of only 50 s for the first biopsies that they performed, and they significantly reduced this time as they gained experience in performing this procedure (7, 16). The complexity of the procedures, due to the intricate topography, to the small size of the target lesions or to the high number of manipulations, can indeed increase the RT-CT fluorometry times. It is therefore hard to compare the RT-CT fluorometry times obtained in different studies without also taking the specific features of the target lesions into account. We noted that the times were much shorter for biopsies than for drainages, which is in line with previously reported results (4, 15).

Several authors were right to point out that the major drawback of RT-CT fluorometry is the high radiation exposure for the patient and operator (1, 2, 4, 17-19), with 10-fold higher magnitude levels than those obtained with standard CT guidance without RT-CT fluorometry (20). Several options have been proposed to overcome this problem. In particular, the cumulated RT-CT fluorometry time should be limited and the delivered dose could be very substantially reduced by lowering the amperage (18). As reported by Nawfel et al. (19), at certain dosage levels, signs of the determinstic effects of irradiation may be noted on the patient’s skin (e.g. erythema) during RT-CT fluorometry. The irradiation level can be considerably reduced by lowering the amperage, as clearly shown by Nawfel et al. (19).

According to these authors, the entrance skin dose obtained at 120 kV and 50 mA is about half that obtained at 120 kV and 90 mA (19). Carlson et al. proposed the intermittent use of RT-CT fluorometry (Quick-Check) to achieve satisfactory monitoring of needle advancement, while also substantially reducing radiation exposure (5). Another problem is that the operator’s hand is often exposed to the X-ray beam (2, 19), with an entrance hand exposure dose of around 0.76 mSv (18). Based on a maximum entrance dose of 2.2 mGy per procedure (with the hand 10 cm from the detector plane, an RT-CT fluorometry time of 80 s, kilovoltage of 120 kVp, and amperage of 50 mA), Nawfel et al. (19) demonstrated that the monthly hand exposure dose for an operator performing 10 procedures a month is 22 mGy. It is thus essential to use a needle guidance system in order to avoid exposure of the operator’s hand to the X-ray beam (2, 5). As Irie et al. pointed out, exposure of the operator’s hand to radiation can be avoided by using needle forceps (21). The operator’s hand radiation exposure dose can be reduced by 71% if the hand is kept 10 cm away from the section plane. The use of needle forceps is thus highly recommended. Different models are available (5), but our experience has shown that surgical dressing forceps provide an effective cost-effective alternative. The use of a lead apron can also reduce the entrance hand exposure dose by almost half, i.e. from 0.41 mSv to 0.76 mSv according to Irie et al. (22). The extent of operator hand exposure to radiation can be considerably reduced by lowering the amperage. Irie et al. showed that the dose to which the operator’s hand is exposed is reduced by 40% when the amperage is adjusted from 120 kV and 30 mA to 135 kV and 50 mA (22). With our equipment set up, we are able to obtain very satisfactory RT-CT fluorometry images at 120 kV and 21 mAs, so this is the amperage we use for routine CT imaging. Finally, the use of lead gloves reduces the entrance operator hand exposure by 97% (23) so this seems to provide the best radiation shielding.

Our study had several limitations. First, as it was a retrospective study, there was a lack of patient follow-up data to determine the overall needle drainage and biopsy efficacy. Moreover, we aimed to assess the advantages of RT-CT fluorometry with respect to the technical aspects of the interventions, but not to reevaluate the efficacy of percutaneous drainage in abscess treatment or of percutaneous biopsy in the diagnosis of abdominopelvic masses, since these aspects are already well documented. The second (and to our mind the most important) limitation was the lack of dosimetric data. Throughout our procedure period, dosage levels were not automatically calculated by the instrument or displayed on the screen at the end of the procedure. It was therefore not possible for us to retrospectively come up with these data.

Conclusion

The results of our initial clinical study suggested that RT-CT fluorometry could be used for the guidance of abdominopelvic interventional procedures with a very high success rate. It is hard to determine the real advantages of using this interventional guidance technique as no data are available for a direct comparison with procedures without guidance. However, we successfully used RT-CT fluorometry to guide seemingly difficult percutaneous biopsies. Due to substantial radiation exposure, its use should be limited to specific cases involving complex procedures with hard to access targets. It would thus now be essential to draw up a manual of good RT-CT fluorometry practices that would cover the indications that can be managed by this technique, and the operational features.

References