Abdom Imaging 25:633–637 (2000)
DOI: 10.1007/s002610000072

Abdominal Imaging

CT fluoroscopic guidance for percutaneous needle placement into abdominopelvic lesions with difficult access routes

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Received: 8 December 1999/Revision accepted: 5 April 2000

Abstract

Background: We wished to evaluate the utility of computed tomography fluoroscopy (CTF) for guiding percutaneous abdominopelvic biopsies or fluid aspirations that are considered difficult with conventional computed tomographic (CT) guidance.

Methods: CTF-guided percutaneous biopsy ($n = 11$) or fluid aspiration ($n = 2$) was attempted in 13 patients with lesions that were otherwise difficult or potentially unsafe by conventional CT guidance because they were deep to colon, small intestine, or major blood vessels.

Results: Using CTF assistance to guide external compression or needle positioning, appropriate needle placement was performed in 11 patients. Biopsy or aspiration was diagnostic in 10 patients. Needle advancement was not attempted in two patients.

Conclusion: CTF appears to be a valuable tool to dynamically assist percutaneous needle placement into lesions that may be considered difficult with standard CT assistance.

Key words: Abdomen, interventional procedures—Access, drainage—Biopsies, technology—Computed tomography, guidance—Fluoroscopy, technology.

Computed tomography fluoroscopy (CTF) has been used for a variety of abdominal and pelvic procedures including biopsy, fluid collection aspiration or drainage, percutaneous ethanol ablation, sympathectomy, preoperative hepatic tumor localization, and ethanol injection of hepatocellular carcinoma [1–6]. Several studies have suggested that using CTF assistance for percutaneous procedures of the abdomen and pelvis results in increased needle accuracy and decreased procedure time compared with conventional computed tomography (CT) guidance [5, 7–8]. Its usefulness in performing procedures that would be difficult to perform with conventional CT guidance, however, has yet to be determined. Our study evaluated the utility of CTF for guiding needle placement into abdominal or pelvic lesions that were deep to vital structures, thereby limiting the safety of percutaneous approach with conventional CT guidance.

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Materials and methods

Between March 1998 and August 1999, we attempted percutaneous aspiration ($n = 2$) or biopsy ($n = 11$) of 13 abdominal or pelvic lesions by using CTF to guide needle placement in 13 patients. The patients included seven men and six women, with an age range of 42–85 years (mean = 64 years). All 13 lesions were discovered on recent (<2 weeks old) helical CT scans. Eight of the 11 patients with solid lesions had recently discovered or previously treated malignancy (three endometrial carcinomas, two colon carcinomas, one ovarian carcinoma, one transitional cell carcinoma, and one lymphoma). Both patients with fluid collections had undergone recent surgery (one radical prostatectomy and one anterior abdominal wall hernia repair). Five lesions were abdominal retroperitoneal, four were abdominal nonretroperitoneal, and four were pelvic. All lesions were deep to either colon ($n = 2$), small intestine ($n = 3$), small intestine and colon ($n = 7$), or iliac artery and vein ($n = 1$). A posterior approach was contraindicated because of overlying spine, aorta, inferior vena cava, or kidney.

Two radiologists reviewed diagnostic CT scans when biopsies were requested to determine the feasibility of percutaneous needle placement for biopsy or aspiration with conventional CT guidance. Two patients who met initial criteria for the study in that their lesions were potentially unsafe to access or initial diagnostic CT scans were excluded at the time of CTF imaging because they were able to be positioned, or the gantry tilted, in a manner allowing a safe linear percutaneous approach to the target lesion.

All patients were biopsied on the same CTF system (Xpress SX, Toshiba America Medical Systems, Tustin, CA, USA). Lesions were localized before biopsy by using either conventional CT or CTF. Once lesions were localized, prebiopsy CTF scanning was performed to determine whether a linear window for percutaneous needle placement was possible. Scanning of mobile lesions was performed while the patient achieved a controlled breath-hold [1]. After lesions were localized, external compression of intervening colon or small bowel was applied with a hand-held plastic needle holder (Civco, Kolona, IA, USA) to create a window for biopsy. If a suitable approach was deemed possible, the patients were sterilely prepped and draped.

When external compression was required to create a window, a two-handed method was used [9]. With this technique, one hand was used to guide compression with the plastic needle holder, and the other hand was used to advance the needle with the aid of a 25-cm-long stainless steel surgical hemostat (Mayo-Hegar, Codman, Boston, MA, USA). In those lesions where displacement of overlying structures was not required, needle advancement was performed with a one-handed technique whereby the needle was held, angled, and advanced with the use of the metallic surgical hemostat [9].

In four instances, a coaxial system was used, and 22-gauge fine needle aspiration (FNA) was performed through an 18-gauge needle. Otherwise, needle choices included an 18-gauge coaxial automated core biopsy device ($n = 3$), a 22-gauge FNA needle without coaxial assistance ($n = 2$), an 18-gauge needle ($n = 1$), and a 4-French sheathed needle ($n = 1$). Our choice of needles differed depending on the clinical situation. For instance, we used an 18-gauge core device for instances where lymphoma was a possibility. We used small-caliber FNA biopsy needles for suspected metastatic lymphadenopathy. For small and large fluid collections, we used an 18-gauge needle and a 4-French sheathed needle, respectively. We prefer larger caliber needles alone or as part of a coaxial delivery system to minimize needle bowing related to the use of needle holders and real-time needle manipulation [4, 9].

Imaging parameters for CTF (120 kVp and 50 mA per second, 10-mm collimation, and image reconstruction rate of 6 frames/s) were the same in all patients. Continuous CTF was used to perform lesion localization in the axial plane and to perform procedure planning for those lesions requiring displacement of overlying structures. In several instances, intermittent CTF was used only for needle advancement through the abdominal wall. Otherwise, needle advancement was performed with continuous CTF guidance. Postprocedure scanning was performed with conventional CT scanning. Total CTF exposure time was recorded in all patients.

Biopsies were considered successful if the target lesion could be biopsied with CTF guidance and if the final pathology report indicated that the specimen was satisfactory for diagnosis. Fluid collection analysis included Gram stain and culture. Imaging and clinical follow-up were sought in all patients; clinical follow-up was performed by review of medical records.

Results

Satisfactory needle position for biopsy or fluid aspiration was obtained in all 11 patients in whom biopsy was attempted. In six patients, overlying bowel was displaced with an external compression device during CTF to create a safe window for linear needle advancement (Fig. 1). In four patients, a needle was directed around vital structures in real time. In one patient, a combination of external compression and directing the needle around vital structures was required for satisfactory needle placement (Fig. 2). Biopsy was not attempted in two patients because colon could not be safely displaced.

For solid lesions, mean lesion diameter was 2.0 cm (range = 1.5–4.0 cm). The two fluid collections measured 2 and 5 cm maximum in diameter, respectively. In five instances where the percutaneous needle was directed around vital structures, final needle position was 5–33 degrees different from the original needle entry position.

In the two instances where FNA biopsy was performed, two passes were required to obtain an adequate sample, as dictated by an attending cytopathologist. In four biopsies where a coaxial system was used, one pass was required for satisfactory placement of the outer needle. Subsequently, from one to three aspiration biopsies (mean = 2) were required for diagnosis. In three instances where a coaxial core biopsy device was used, one pass each was required for satisfactory positioning of the needle. Subsequently, three core biopsies were obtained in each patient. Only one needle pass each was required in the two patients with focal fluid collections.

Fluid aspiration in the two patients with fluid collections showed pyogenic abcess ($n = 1$) and sterile fluid ($n = 1$). In the patient with a pyogenic abcess, the fluid collection was completely aspirated. Pathology results for the nine patients who underwent percutaneous biopsy included metastatic disease ($n = 5$), lymphoma ($n = 1$), retroperitoneal fibrosis ($n = 1$), benign disease ($n = 1$), and inconclusive specimen ($n = 1$).

Of the latter three patients, two subsequently underwent open surgical biopsy. For the patient whose percutaneous biopsy showed retroperitoneal fibrosis, the same diagnosis was confirmed surgically. The patient whose percutaneous biopsy result was inconclusive had suspected recurrence of lymphoma in the central mesentery. With CTF guidance, three core biopsies were obtained with an 18-gauge automated core biopsy device; however, the quantity of lymphoid tissue proved insufficient for subtyping. A subsequent laparotomy showed a tiny residual hematoma within the target lymph node, confirming satisfactory needle placement during the percutaneous biopsy.

The patient whose biopsy showed benign disease eventually underwent surgery for small bowel obstruction. Surgical evaluation and resection of the mass that had been biopsied with CTF confirmed the presence of a benign fibrosis from previous surgical therapy.

Of the two patients in whom biopsy was not attempted, one underwent an open laparotomy, which showed benign disease. The other is awaiting laparotomy. All patients tolerated their biopsies well. Postprocedure imaging and clinical follow-up in all patients showed no evidence of complications.

All procedures, with one exception, were performed by the same operator (G.D.S.). Mean CTF exposure time for those patients with satisfactory needle position was 530 s (range = 196–784 s). CTF exposure times for the two patients who did not undergo biopsy were 100 and 236 s.

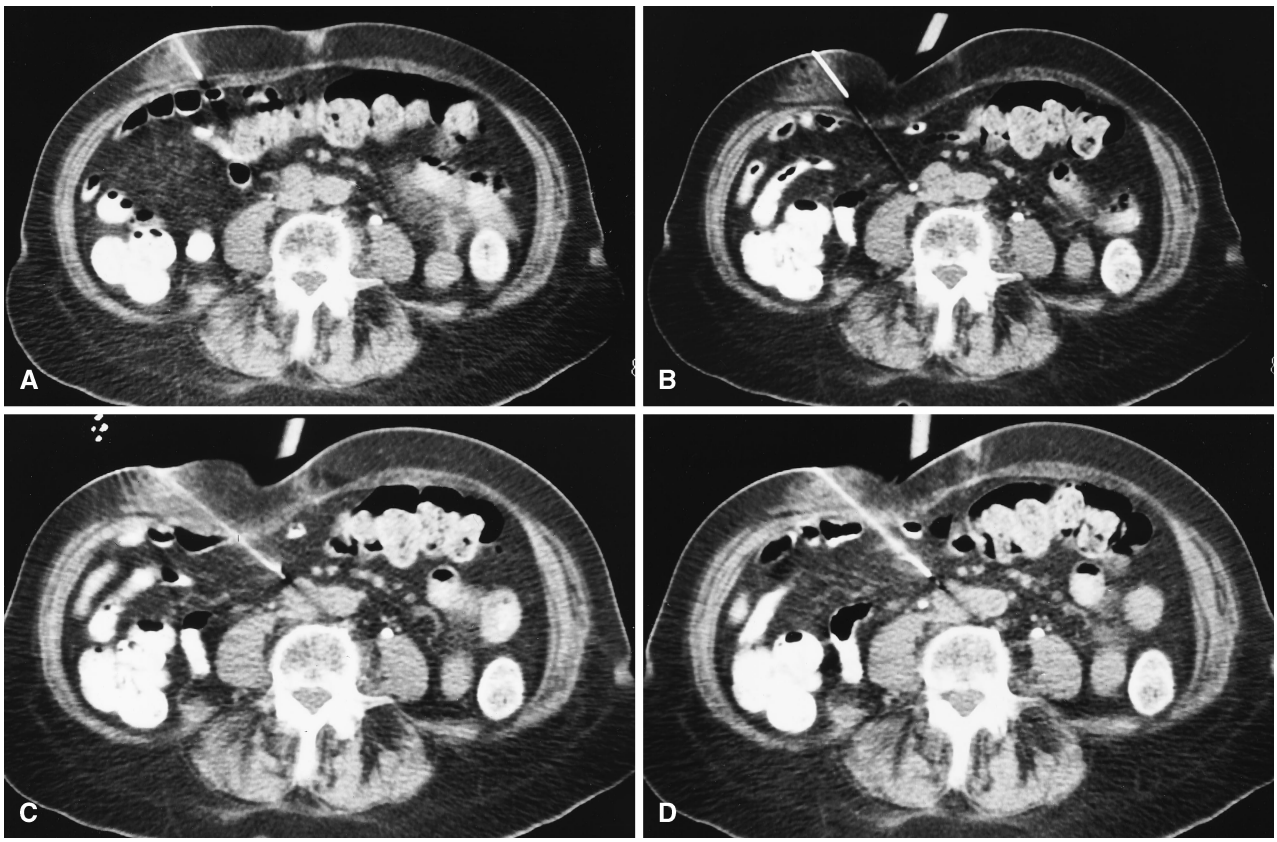

Fig. 1. Reconstructed sequential CTF images from a percutaneous biopsy in an 85-year-old female with small precaval lymph node. **A** The initial image, obtained without extrinsic compression, demonstrates the colon interposed between the 18-gauge procedure needle and the abnormal lymph node. **B–C** Subsequent images after displacement of the colon by extrinsic compression show advancement of the 18-gauge needle to the edge of the lesion. **D** Needle position before coaxial fine needle aspiration biopsy with a 22-gauge needle. Metastatic endometrial carcinoma was confirmed histologically.

Discussion

Safe and successful performance of percutaneous procedures depends on a number of variables including lesion accessibility, coagulation status, and the ability of the patient to cooperate [10–11]. Although an infrequent occurrence, lesions may be located in such a way as to prevent a safe linear approach with conventional CT guidance. Although transgression of the small intestine during percutaneous biopsy or intervention is not absolutely contraindicated, needle passage through the colon and major blood vessels is generally contraindicated [11].

The use of an external compression device to displace overlying bowel for conventional CT-guided percutaneous procedures has been previously described [12–13]. The use of an external compression device without additional needle maneuvering, however, may be inadequate if overlying bowel cannot be completely displaced.

By using CTF assistance to guide external compression or needle placement around vital structures (either singly or in combination), we were able to obtain adequate tissue or tissue for histologic, cytologic, or microbiologic diagnosis in 10 of 13 patients. No diagnoses were false negative.

Large-caliber needles are preferred for CTF because they allow better needle control when a needle holder is used [4, 9]. Although two of our cases were performed with 22-gauge FNA needles only, we preferred large-caliber needles because they were more easily finessed around intestine or colon than smaller gauge needles. Furthermore, the large-caliber needles allowed biopsies to be performed coaxially, thereby minimizing the number of passes required to reach the target lesions.

One difficulty we encountered in those patients who required extrinsic compression was the use of the plastic needle holder as a compression device. In our experience, when compression was applied, the plastic needle holder was difficult to direct in an angle that was optimal for needle advancement. This problem was circumvented in subsequent cases by using the plastic device only for compression and not for holding the portion of the needle closest to the patient. These latter cases required the use

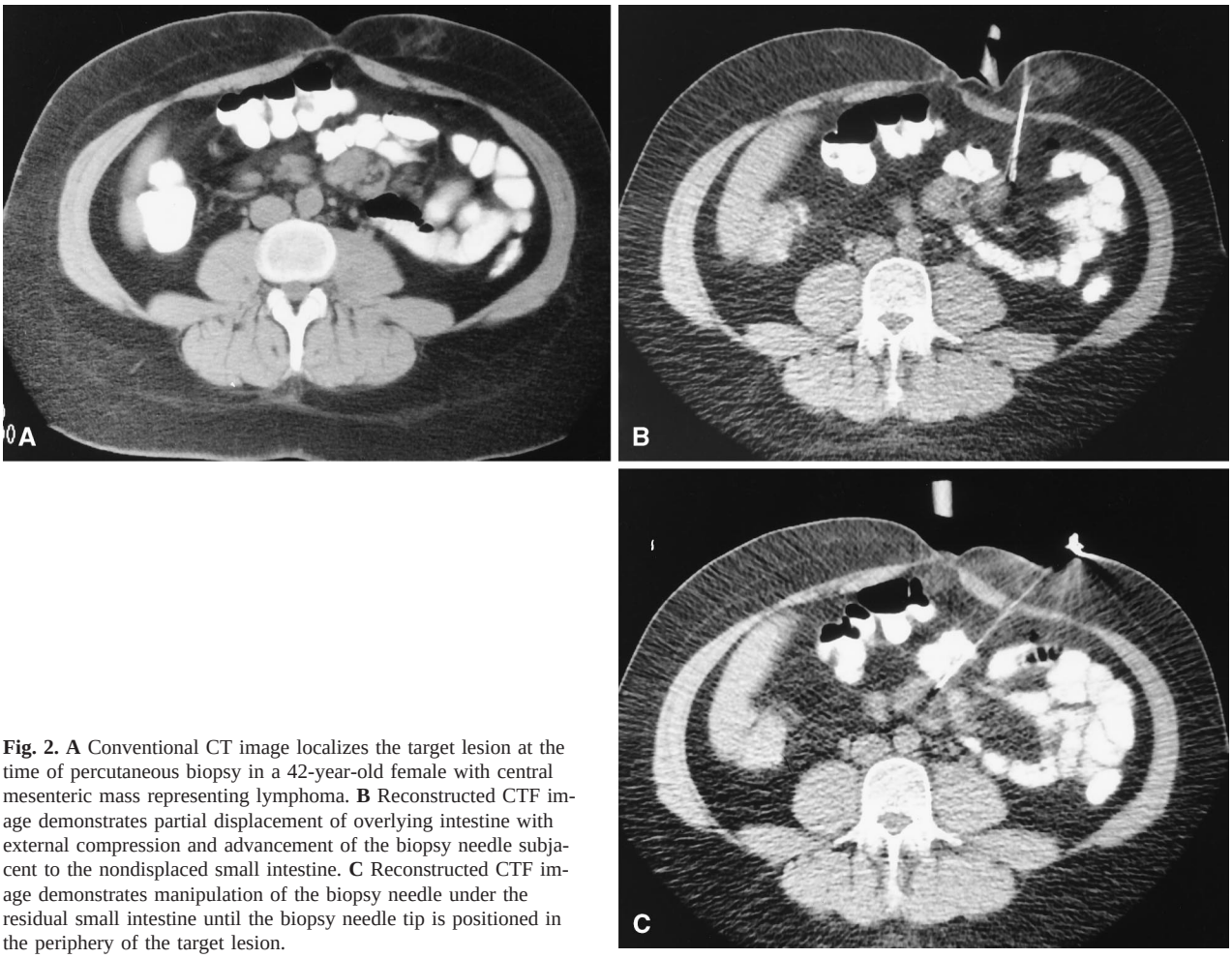

Fig. 2. A Conventional CT image localizes the target lesion at the time of percutaneous biopsy in a 42-year-old female with central mesenteric mass representing lymphoma. **B** Reconstructed CTF image demonstrates partial displacement of overlying intestine with external compression and advancement of the biopsy needle subjacent to the nondisplaced small intestine. **C** Reconstructed CTF image demonstrates manipulation of the biopsy needle under the residual small intestine until the biopsy needle tip is positioned in the periphery of the target lesion.

of 18-gauge or larger caliber needles to minimize the effects of needle bowing.

Of the two patients in whom CTF guided biopsy was not attempted, one had a 2-cm-diameter lesion subjacent to redundant transverse colon. The overlying colon could be moved with external compression, but the mass could not be separated from the colon. The other patient had a 1.5-cm-diameter paraaortic lesion in the upper abdomen. The colon could not be displaced in this patient, probably because of scarring from multiple previous abdominal surgeries. In both cases, external compression was coupled with gantry tilting.

One facet that we did not explore in all patients was the use of ultrasound (US). It is well documented that US is beneficial for percutaneous biopsy of small abdominal, pelvic, and retroperitoneal lymph nodes. In one study by Memel et al., abdominal, pelvic, and retroperitoneal lymph nodes were visualized and biopsied in 21 of 26 cases [14]. The lack of ionizing radiation, lower cost, and portability of US are distinct advantages over CTF guidance. However, its relative advantages over CT guidance, including the ability to displace overlying bowel and fix relatively mobile lesions with extrinsic compression, may not be as clear-cut as once thought with the availability of CTF.

With our imaging parameters, 120 kVp and 50 mA, the estimated absorbed skin and bone marrow doses to the patient are 396 and 120 mrad (3.96 and 1.20 mGy) for each second of exposure [4, 15]. Although CTF time was relatively high for our patients compared with general abdominal intervention using CTF guidance at other institutions [5–6], it is likely a reflection of a combination of factors including the use of continuous CTF for lesion localization with and without abdominal wall compression, our lack of a compression device through which biopsies can be performed, and the difficult nature of cases described herein. We believe total radiation exposure could be reduced with the use of intermittent CTF for those lesions where extrinsic compression was used without associated real-time needle repositioning [13].

Our results demonstrate that CTF may be used to attempt percutaneous abdominal and pelvic procedures with patients for whom percutaneous procedures with standard CT guidance might otherwise be considered

difficult or unsafe due to risk of transgressing the intervening structures. The real-time capabilities of CTF assisted in creation of a safe window for needle advancement and allowed real-time positioning of the needle tip around structures where needle transgression was undesirable.

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