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A Comparative Study of CT Fluoroscopy Combined with Fluoroscopy Versus Fluoroscopy Alone for Percutaneous Transhepatic Biliary Drainage

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Abstract

Purpose: We compared CT fluoroscopy (CTF) for the initial puncture of bile ducts with conventional fluoroscopic guidance in patients with malignant jaundice in whom percutaneous transhepatic biliary drainage (PTBD) was planned.
Methods: Forty consecutive patients were randomized to two study groups: group A underwent PTBD under CTF and fluoroscopic guidance, group B underwent PTBD under fluoroscopic guidance alone. CTF-guided PTBD was performed using a combination of a helical CT scanner of the latest generation and a mobile C-arm; conventional PTBD was performed under fluoroscopic guidance in the angiographic unit. End points of the study were the success (a puncture that enabled safe placement of a guidewire in a suitable bile duct) and the complication rate (hemobilia, bile fistula, biliary peritonitis), the number of punctures required, the time needed for successful puncture of a suitable bile duct, and the patient's radiation exposure.
Results: CTF-guided puncture of peripheral bile ducts suitable for PTBD was successful at the first attempt in 16 cases, under conventional fluoroscopic guidance, in only two cases. We found a significantly different number of punctures (1.2 in group A vs 2.9 in group B), a significantly shorter time for puncture in group A (mean 39 sec), but also a significantly higher skin exposure dosage in group A (mean 49.5 mSv surface dosage). There was no significant difference regarding the total procedure time. Only one complication occurred in group B (portobiliary fistula).
Conclusion: CTF-guided initial puncture of bile ducts allowed a significantly reduced number of punctures and puncture times compared with puncture under conventional fluoroscopic guidance for placement of percutaneous transhepatic biliary drainage catheters.

Key words: Computed tomography, guidance—Computed tomography, radiation exposure—Fluoroscopy—Biliary drainage

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Real-time CT fluoroscopy (CTF), also called real-time CT, was investigated in 1994 by Katada et al. [1] and has been increasingly used in nonvascular interventions. The method combines the advantages of ultrasound (real-time sectional imaging) and CT (minor susceptibility to bone and air artifacts). It has been described recently for percutaneous transhepatic biliary drainage (PTBD) or stenting of the biliary tract [2].

In a prospective study we compared the usefulness of CTF for the initial puncture of bile ducts with conventional fluoroscopic guidance in patients with malignant jaundice in whom PTBD was planned.

Materials and Methods

Between October 1998 and December 1999 we enrolled 40 consecutive patients suffering from obstructive jaundice due to histologically proven malignant disease in whom endoscopic drainage was impossible. The patients were randomized into two study groups: group A, CTF-guided puncture of a suitable bile duct for PTBD; group B, fluoroscopic-guided PTBD. The study was carried out in accordance with the Helsinki Declaration and written informed consent was obtained from all patients.

In group A, PTBD was performed using a combination of a helical CT scanner (Somatom Plus 4 Power, Siemens, Forchheim, Germany) and a mobile C-arm (Siremobil Compact, Siemens) (Fig.

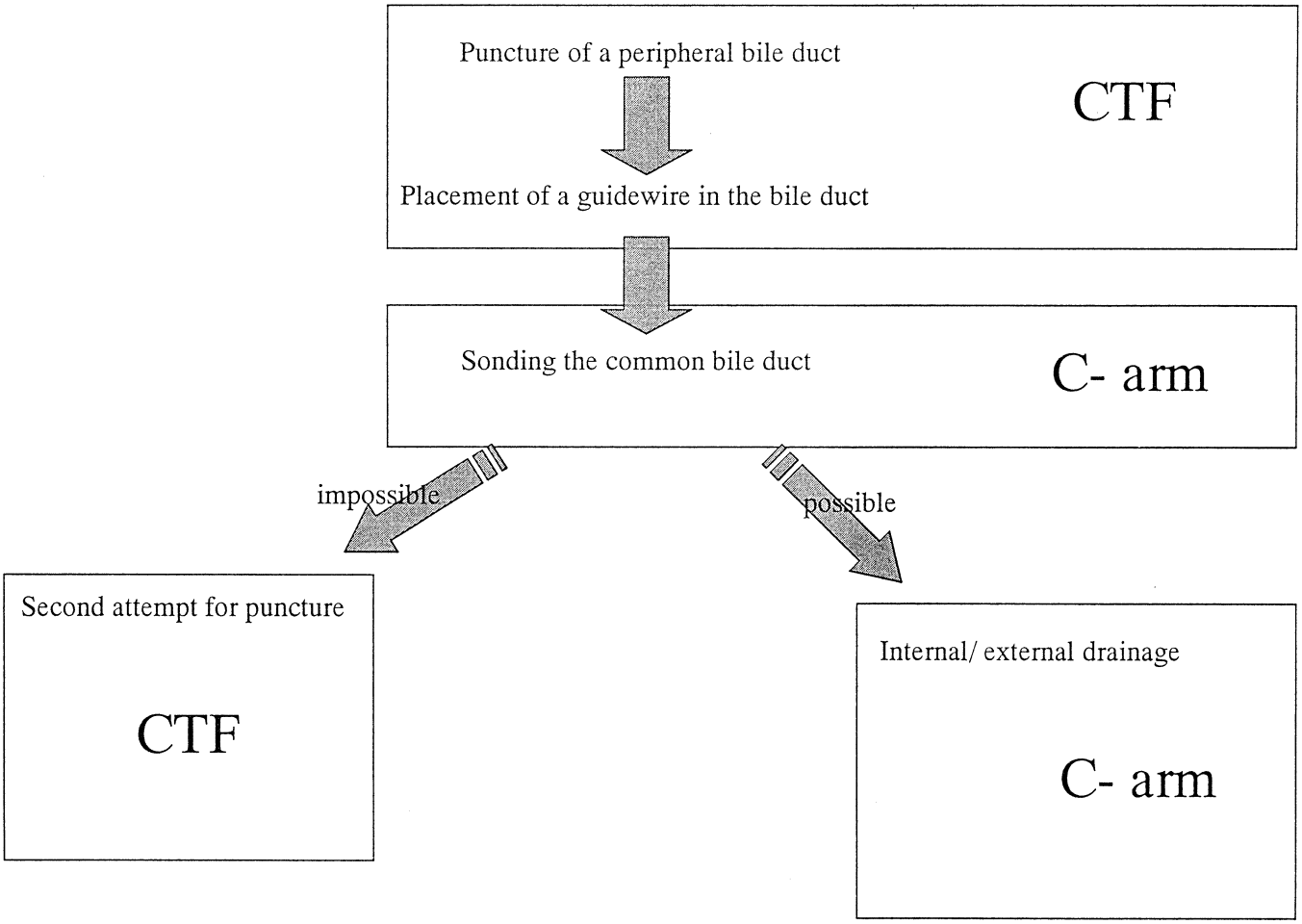

Fig. 1. The study design for group A (CTF-guided puncture). In group B the entire procedure was performed under fluoroscopic control.

1). The CT system enables real-time reconstruction of the sectional planes (50 mA tube current, 120 kV tube voltage) on a monitor in the examination room with up to 8 frames/sec over a period of 79 sec without interruption; after a short pause (2–3 sec) another 79 sec of CT fluoroscopy is available.

First CTF was performed to select a suitable peripheral bile duct. To be "suitable" the bile duct should have a width of at least 4 mm. The decision to puncture the right or left liver lobe was made on the basis of the maximal width of the bile ducts or the most suitable approach. After local anesthesia and skin incision, direct puncture of the selected bile duct was performed under CTF guidance (slice thickness 8 mm, 120 kV tube voltage, 50 mA, time of rotation 0.75 sec, 8 frames/sec) using a 5 Fr UNI-Dwell needle with mandrin (Angiomed, Karlsruhe, Germany) (Fig. 2). The correct position was proved by injection of a small amount of contrast medium under CTF control. The time between skin incision and CTF control of the correct position was recorded as "puncture time".

Next a 0.035-inch Terumo guidewire was inserted and a 7 Fr peel-away sheath introduced. Recanalization of the occluded segment of the bile tract was performed using the usual two-step technique with temporary insertion of a combined internal/external drainage system (PTC-catheter model Wiesbaden, Angiomed). The time between skin incision and completion of the internal/external drainage was recorded as "total procedure time".

Definitive stenting of the occlusion was performed during a second selective procedure after a 3-day period of internal/external drainage. First a stiff guidewire was introduced over the drainage catheter. Then the drainage catheter was exchanged for a premounted stent device (7 Fr Placehit Wallstent, Boston Scientific, Ratingen, Germany). The embolization of the puncture site was later performed by means of two or three stainless steel embolization coils (William Cook Europe, Bjaeverskov, Denmark) during removal of the sheath.

We determined the number of punctures necessary to locate a suitable bile duct, the width (measured on images after filling with contrast medium) and the anatomic location of the duct as well as the distance between the liver surface and duct insertion. A successful puncture was defined as one that enabled safe placement of a guidewire in the bile duct. Because the examinations were performed in daily practice no thermoluminescent dosimetry (TLD) measurements were performed, which is a limitation. The surface dose was calculated [3] assuming 4.5 mSv surface dose per second of CT fluoroscopy.

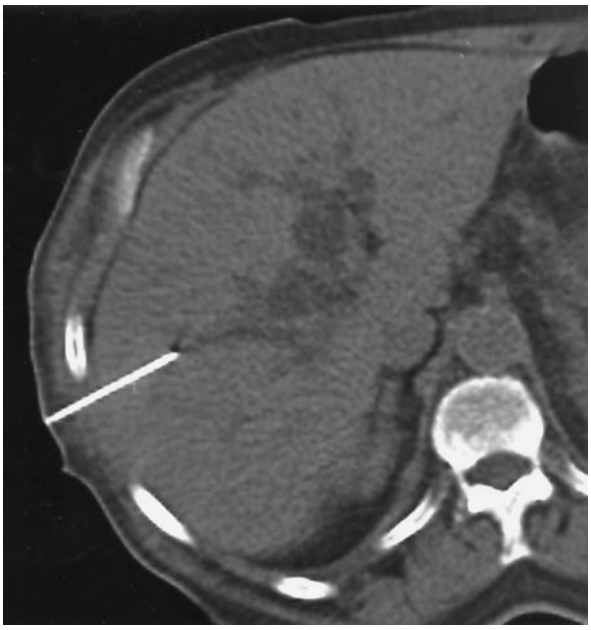

Fig. 2. CTF spot (slice thickness 8 mm, 120 kV, 50 mA, time of rotation 0.75 sec) shows moderately enlarged peripheral bile ducts and clearly dilated central bile ducts. The puncture needle is positioned in a peripheral vessel of the right liver lobe (needle tip sign). The correct placement in the bile duct (and not in a portal vein branch) was then proven by injection of a small amount of contrast medium (not shown).

The results were compared with those obtained in the 20 patients of group B who were treated by fluoroscopic-guided PTBD in the angiographic unit (Multiskop/Koordinat S and Polytron 1000S, Siemens). Fluoroscopy was performed with a variable tube current and a tube voltage of 80 kV. The approximate surface dose was calculated using the kerma area product (cGy cm^2).

In this group we performed a fine needle (22 G) blind puncture of the liver using a percutaneous access set consisting of a 22 G needle, a 0.018-inch nitinol guidewire, an introducer with stiffening cannula, and an outer sheath (NPAS-100-NT, William Cook Europe).

The significance of differences regarding the end points of the study was tested by means of the Mann-Whitney *U*-test.

Results

In summary we have treated 40 patients suffering from bile duct obstruction caused by malignant tumor in the reported manner. There was no statistically significant difference between the two study groups regarding sex, age, or underlying disease (Table 1). All patients showed high-grade stenosis or occlusion of the common bile duct. In 29 of the patients endoscopic passage was impossible because of the high rigidity of the stenosis/occlusion; in 11 patients the papilla could not be reached because they had undergone Whipple's operation or Bilroth II resection of the stomach.

In all cases the peripheral bile ducts could be differentiated from peripheral portal vein branches without administration of intravenous contrast medium. The correct positioning of the puncture needle in the peripheral bile duct was proven by injection of contrast medium. The smallest identified bile duct showed a width of only 4 mm (median 6 mm, range 4–12 mm).

Table 1. Demographic data of the two study groups

	Group A (n = 20)	Group B (n = 20)
Age (years)	58 (43–74)	56 (51–72)
Sex (male:female)	14:6	11:9
Etiology		
Bile duct carcinoma	12	9
Pancreatic cancer	5	6
Metastases	3	5
Bilirubin before PTBD (mg%)	11.2	12.9

Group A = CTF-guided percutaneous transhepatic biliary drainage (PTBD); group B = fluoroscopic-guided PTBD.

CTF-guided punctures were successful at the first trial in 16 cases; in four cases we needed two attempts. The distance between the liver surface and the duct insertion ranged from 2.8 to 5.7 cm (median 3.9 cm). The approach was via a peripheral bile duct of the right liver lobe in 17 cases and via a peripheral bile duct of the left liver lobe in three cases. The time of CTF ranged between 5 sec and 21 sec (median 11 sec). Thus, following the above-mentioned calculation, the surface dose approximately ranged between 22.5 mSv and 94.5 mSv with a median of 49.5 mSv. The puncture time ranged between 31 sec and 55 sec (median 39 sec). The total procedure time ranged between 15 min and 26 min (median 19 min). The total time for CTF and C-arm fluoroscopy ranged between 24 sec and 52 sec (median 40 sec).

There were no complications during the CTF-guided puncture. In all cases insertion of the guidewire into the central biliary system was possible. In only two cases was passage through an occlusion of high rigidity impossible. These patients were supplied with external drainage and there was no second attempt to recanalize the obstruction. In the other cases the PTBD catheter as well as the Wallstent were introduced without any problem.

Fluoroscopic-guided punctures were successful at the first attempt in two cases, at the second attempt in five cases, at the third attempt in six cases, and in seven cases four attempts were needed. Thus on average 2.9 attempts were needed. The approach was via a peripheral bile duct of the right liver lobe in 19 cases, via the left liver lobe in one case.

The fluoroscopy time during the puncture ranged between 7 sec and 68 sec (median 34 sec). Thus the surface dose related to the fluoroscopic-guided puncture approximately ranged between 1.3 mSv and 8.6 mSv (median 4.1 mSv). The puncture time itself ranged between 32 sec and 105 sec (median 70 sec). The total procedure time ranged between 14 min and 28 min (median 20 min). The total fluoroscopy time ranged between 38 sec and 92 sec with a median of 65 sec. In this group we found one fistula between the portal and biliary system. In three cases further passage through the occlusion was not possible and the patients were supplied

Table 2. Comparison of the results

	Group A			Group B			Test	
	Median	Mean	± SD	Median	Mean	± SD	*t*	*p*
Width of bile duct (mm)	6	6.55	2.03	–	–	–	–	–
Distance from surface to bile duct (mm)	39	39.5	9.51	–	–	–	–	–
Puncture attempts (*n*)	1.0	1.2	0.41	3.0	2.90	1.02	−4.49	0.0000
Puncture alone								
Time of CTF/fluoroscopy alone (sec)	11	12.8	4.91	34	35.4	17.7	−4.06	0.0000
Total time (sec)	39	41.65	6.47	70	69.4	21.9	−3.89	0.0001
Skin dosage (mSv)	49.5	52.7	21.6	4.1	4.32	0.48	5.0	0.0000
Whole procedure								
Time of CTF + fluoroscopy/fluoroscopy alone (sec)	40	43.05	5.2	65	64.8	16.3	−4.20	0.0000
Total time (min)	19	19.05	3.05	20	18.9	3.58	0.189	0.8498

Group A = PTBD under CTF and C-arm guidance; group B = PTBD under fluoroscopic guidance alone.

with external drainage without any further attempt at recanalization.

Comparison of the Punctures Under CTF and Fluoroscopic Guidance (Table 2)

The differences regarding the number of attempts required and the time for puncture were statistically significant: the CTF-guided procedure needs fewer trials and a shorter time to locate a suitable bile duct. The total procedure time was not significantly different between groups. The estimated skin dosage during puncture as a measure of a patient's radiation dosage was significantly higher in group A.

Discussion

PTBD and bile duct stenting, which were first reported by Hoevels et al. [4] in 1978, have become widely accepted methods [5–7]. It is now commonly used in the palliative treatment of obstructive jaundice caused by malignancy in those cases which can not be treated by endoscopic methods [4, 8–13]. One important condition for successful PTBD and recanalization of the occluded segment is the puncture of a suitable peripheral bile duct with an obtuse angle to the central biliary system, which is commonly performed under fluoroscopic or sonographic guidance. Nevertheless, both the fluoroscopic and sonographic approach have limitations. One disadvantage of fluoroscopic control is the lack of a sectional view. Ultrasound shows major susceptibility to air and bone artifacts.

As early as 1977 Haaga et al. [14] described interventional CT guidance as an effective method for obtaining diagnostic specimens and provide drainage in selected patients. Since then several authors have reported that CT-guided puncture of both thoracic and abdominal masses has a high diagnostic accuracy [15–17] with a specificity ranging from 66% to 97.5%. CT-guided drainage was also reported as a highly effective therapy and successful in up to 87% of cases [18]. Today CTF, which was introduced by Katada et al. [1, 19] in 1994, enables real-time imaging, and combines the advantages of ultrasound and CT.

Potential benefits of the method have been described recently [20–25] and it was recently recommended for the puncture of peripheral bile duct during PTBD also [2].

In a comparative study we evaluated the benefit of CTF compared with fluoroscopy for guidance of PTBD. Our results demonstrate that puncture of a suitable bile duct is performed faster and is less traumatic under CTF than fluoroscopic control because the number of attempts required to puncture the bile duct is significant lower under CTF, which is in accordance with the findings of Froelich et al. [2]. This fact is somewhat surprising, because the visualization along the *Z*-axis is difficult in CTF and the bile ducts are rarely located in the transverse section of a CT slice. Also CTF achieves only limited spatial resolution and therefore only clearly dilated bile ducts with a width of at least 4 mm can be punctured easily. Nondilated or mildly dilated bile ducts might not be amenable to CTF-guided puncture. Although most radiologists perform a contrast-enhanced spiral-CT scan to distinguish dilated bile ducts from portal vein branches we did not administer intravenous contrast medium in the present study.

In our study no patient suffering from obstructive jaundice due to a tumorous mass at the confluence of the hepatic ducts was treated. The potential benefit of CTF in such cases calls for additional investigation.

The fact that we used 8-mm slice thickness is a possible limitation of our study. The results could possibly have been improved by the use of a smaller slice thickness.

The width of the bile duct and the distance between body surface and punctured bile duct were evaluated in only group A, because these parameters can only be estimated on the fluoroscopic image.

There was no significant difference between the two study groups regarding the total procedure time: this time is determined in the main by the procedure following the puncture.

The most serious disadvantage of the CTF-guided procedure is the increased radiation exposure for both patient and investigator. It is a limitation of our study that no direct measurement of the radiation dosage was done, but TLD measurements are difficult to perform in daily practice. Using a commonly accepted calculation the patient's surface dosage was demonstrated to be significantly higher than under fluoroscopic control. The investigator's dosage, which was not measured in the present study, may be diminished by the use of a needle holder as suggested by Kato et al. [26].

It was not the aim of this study to compare CTF and ultrasound guidance of PTBD, and perhaps a different outcome might be expected if we had compared the combination of CTF and fluoroscopy versus the combination of ultrasound and fluoroscopy.

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