CLINICAL STUDY

Operator Dose Reduction during Transjugular Liver Biopsy Using a Radiation-Attenuating Drape: A Prospective, Randomized Study

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ABSTRACT

Purpose: To assess the effectiveness of disposable radiation-absorbing surgical drapes on operator radiation dose during transjugular liver biopsy (TJLB).

Materials and Methods: This dual-arm prospective, randomized study was conducted between May 2017 and January 2018 at a single institution. TJLB procedures (N = 62; patient age range, 19–80 y) were assigned at a 1:1 ratio to the use of radiation-absorbing surgical drapes or standard surgical draping. The primary outcome was cumulative radiation equivalent dose incident on the operator, as determined by an electronic personal dosimeter worn at the chest during each procedure. Cumulative kerma–area product (KAP), total fluoroscopy time, and total number of exposures used during each liver biopsy procedure were also determined.

Results: Mean radiation dose incident on the operator decreased by 56% with the use of radiation-absorbing drapes (37 μSv ± 35; range, 4–183 μSv) compared with standard draping (84 μSv ± 58; range, 11–220 μSv). Radiation incident on the patient was similar between groups, with no significant differences in mean KAP, total fluoroscopy time, and number of exposures acquired during the procedures.

Conclusions: Use of disposable radiation-absorbing drapes reduces scatter radiation to interventionalists performing TJLB.

ABBREVIATIONS

DSA = digital subtraction angiography, IVC = inferior vena cava, KAP = kerma–area product, ODE = operator dose-equivalent exposure, TIPS = transjugular intrahepatic portosystemic shunt, TJLB = transjugular liver biopsy

In accordance with the "as low as reasonably achievable" principle, radiation dose to patients, operators, and staff should be minimized during x-ray fluoroscopic procedures (1). Although scatter radiation exposure to operators and staff during a single intervention is a small fraction of the patient dose, cumulative exposure over many years can be associated with stochastic and deterministic effects (2–5). Use of protective equipment is therefore important for practicing interventional radiologists and radiology staff (6). Although radiation-attenuating aprons and eyewear may absorb the majority of scatter radiation (7,8), additional protective measures can be considered. One option is the use of sterile radiopaque drapes, which, according to 2010 guidelines jointly produced by the Cardiovascular and Interventional Society of Europe and the Society of Interventional Radiology, should be considered during complex interventional procedures (9).

At present, there are several manufacturers of commercially available, nonlead, heavy-metal drapes designed to attenuate scatter radiation to operators when positioned between the operator and patient. Anthropomorphic phantom studies have demonstrated the potential dose savings to operators during simulated procedures (10,11). Several recent studies in the vascular surgery and cardiology literature have also quantified the operator dose reduction when protective draping is used during interventions on human

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patients (12–17). The extent of the dose reduction has been variable, however. A study of coronary angiographic procedures performed through right radial artery access (15), for example, found an operator dose reduction of 24% at the level of the chest when radiation-attenuating drapes were used. A similar study of radiopaque draping applied at femoral access sites during endovascular aortic repair (13) showed a 55% mean reduction in dose to the operator's chest. A small series of percutaneous nephrostomy tube placement procedures (11) reported 9–29-fold (89%–97%) reductions at various locations on the operators' bodies. To our knowledge, these drapes have not yet been studied during procedures that require a transjugular approach, for which the interventionalist is positioned at the head of the fluoroscopy table.

It was hypothesized that the use of radiopaque surgical drapes (RADPAD; Worldwide Innovations and Technologies, Lenexa, Kansas) would reduce operator radiation exposure during transjugular liver biopsy (TJLB). The goal of this randomized controlled trial was to confirm and quantify the operator dose reduction with protective drapes compared with standard surgical draping.

Table 1. Patient Demographic Data

Variable	Standard Drape	Protective Drape	*P* Value
Sex (M/F)	13/17	17/13	–
Age (y)			.53
Mean ± SD	50.8 ± 15.7	48.0 ± 17.4	
Median	51	51.5	
Range	23–78	19–80	
IQR	35.8–64.0	35.0–59.5	
Weight (kg)			.89
Mean ± SD	82.5 ± 21.8	83.4 ± 26.8	
Median	75.2	78.5	
Range	48.8–136.1	45.4–144.2	
IQR	67.7–97.2	61.4–98.8	
Height (cm)			.32
Mean ± SD	169.4 ± 12.7	166.3 ± 10.4	
Median	170	165	
Range	145–195	149–188	
IQR	160.3–179.5	158.0–174.5	
Transplant status			–
Native	19	25	
OLT	11	5	

IQR = interquartile range; OLT = orthotopic liver transplant; SD = standard deviation.

MATERIALS AND METHODS

Design

The institutional review board of the investigating institution evaluated this pilot randomized trial and determined it to be a minimal-risk quality-improvement study that was exempt from further institutional review board oversight. The trial was conducted at a single tertiary-care facility from May 2017 through January 2018. Its primary endpoint was the cumulative radiation equivalent dose incident on the operator's chest. The minimum sample size for the study was determined to be 50 TJLB procedures (25 per study arm), assuming two-sided 5% statistical significance, 90% power, and a small standardized effect size of 0.2 (18). To compensate for attrition of as much as 25%, 62 identical envelopes containing 1 of 2 study arm assignments were sealed and randomly assorted at the initiation of the study. Randomization occurred via selection of a sealed envelope immediately before each procedure.

Patient Demographics

Demographic characteristics of the 60 patients analyzed are shown in **Table 1**. The patients in each cohort were similar with respect to sex, age, weight, and height. A larger proportion of patients in the standard draping group had a history of orthotopic liver transplantation.

Procedure Description

All TJLB procedures were performed via right internal jugular approach. After obtaining guide wire access into the inferior vena cava (IVC), a 10-F sheath was advanced. Pressure measurements were obtained in the right atrium and IVC. A suitable hepatic vein was accessed with use of a 5-F angiographic catheter. Contrast venography with conventional fluoroscopy or digital subtraction angiography (DSA) was used to confirm appropriate positioning in a vein of adequate size. Free and wedged hepatic venous pressure measurements were then obtained through an occlusion balloon catheter subsequently advanced into the vein. The 10-F sheath in each case was then positioned in the hepatic vein, and a coaxial stiffened cannula was placed through it. Transvenous biopsy specimens were acquired with a core needle biopsy device placed through the cannula. At the conclusion of each procedure, all devices were removed through the jugular access site and hemostasis was achieved with manual compression.

All TJLB procedures were performed on 1 of 2 identical Philips FD20 x-ray angiography systems employing single flat-panel detectors and the AlluraClarity imaging platform (Philips Healthcare, Best, Netherlands). Conventional fluoroscopy was performed with 80-kV nominal tube voltage, 0.7-mm focal spot, and 0.1-mm copper and 1.0-mm aluminum beam filtration at 15 frames per second with 1.0 μGy per frame requested at the detector. Of note, 15 frames per second was the standard frame rate for early implementations of this imaging platform in the United States and was not operator-controlled for most applications.

Dose Monitoring and Draping

Each TJLB procedure was performed by a fellow or resident trainee under the supervision of an attending physician. The