Rivaroxaban versus fondaparinux for thromboprophylaxis after endovenous laser ablation

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Abstract: OBJECTIVE Endovenous heat-induced thrombosis (EHIT) and deep venous thrombosis (DVT) are well-known complications after superficial endovenous thermoablation. We investigated the efficacy of rivaroxaban in preventing EHIT and DVT after endovenous laser ablation (EVLA). METHODS We retrospectively analyzed a consecutive series of patients presenting with truncal varicosis class C to C undergoing EVLA. After EVLA, all patients received oral rivaroxaban (10 mg) or subcutaneous fondaparinux (2.5 mg) once daily for 3 consecutive days. The primary end point was the composite of EHIT or DVT assessed by duplex ultrasound imaging after 1 and 4 weeks. EHIT class 1 was defined as the thrombus extending to the saphenofemoral junction. Extension into the deep venous system with a cross-sectional area obstruction <50% was considered EHIT class 2. EHIT class 3 was defined as >50% cross-sectional area obstruction. EHIT class 4 was total occlusion of the femoral vein. The secondary end points were minor or major bleeding, paresthesia, and skin burns. RESULTS Between February 2009 and December 2015, 391 patients (473 limbs) were treated with EVLA of the truncal saphenous vein. The primary end point occurred in 13 of 166 (7.8%) and 14 of 225 (6.2%) after 1 week and in 13 of 166 (7.8%) and 15 of 225 (6.7%) after 4 weeks comparing the rivaroxaban and fondaparinux groups (P = .659). EHIT class 1 was observed in 20 patients (5.1%) and EHIT class 2 in five (1.3%). No patients had EHIT class 3 or 4. The incidence of DVT was one of 166 (0.6%) in the rivaroxaban group and two of 225 (0.9%) in the fondaparinux group (P = .750). Minor bleeding events occurred in 17 of 166 patients (10.2%) and in 20 of 225 patients (8.9%), respectively (P = .652). No major bleeding events were observed. Paresthesia was observed in 12.5% in the rivaroxaban group and in 17.8% in the fondaparinux group. No skin burns were observed. CONCLUSIONS Rivaroxaban offers an oral medication approach showing no difference in preventing EHIT and DVT compared with fondaparinux, without increased bleeding risk.

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The Effect of a New Angiographic Imaging Technology on Radiation Dose in Visceral Embolization Procedures

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Abstract

Purpose
To evaluate the impact of a new angiographic imaging technology on radiation dose during visceral embolization procedures involving both fluoroscopy and digital subtraction angiography.

Material and Methods
A retrospective analysis from a single-center consecutive series of patients was performed comparing two angiographic imaging systems. The AlluraClarity (CIQ [Philips Healthcare, Best, Netherlands]) was used in 100 patients (n=59 male, mean age: 70.6 years) from July 2013 to April 2014 and compared to the former AlluraXper (AX) technology used in 139 patients (n=71 male, mean age: 70.1 years) from May 2011 to June 2013. Patients were categorized according to body-mass-index (BMI [kg/m^2]) - group 1: BMI <25, group 2: BMI ≥25 and <30, group 3: BMI ≥30. Fluoroscopy time, the total dose of iodinated contrast administered and procedural AirKerma (Ka,r: milli Gray [mGy]) were obtained.

Results
Mean BMI was 26.4±5.0 kg/m^2 in the CIQ and 26.4±7.1 kg/m^2 in the AX group (p=.93). Fluoroscopy time and the amount of contrast media were equally distributed. Ka,r was 1342.9 mGy versus 2214.8 mGy (p<.001, t-test) comparing CIQ to AX. Comparing CIQ to AX, BMI subgroup analysis revealed a mean Ka,r of 970.1 mGy to 1586.1 mGy (p=.003, t-test), 1484.7 mGy to 2170.1 mGy (p=.02, t-test) and 1848.8 mGy to 3348.9 mGy (p=.001, t-test) in BMI groups 1, 2 and 3.

Conclusion
CIQ technology significantly reduced mean radiation dose by 39.4% for visceral embolization procedures at comparable fluoroscopy time and contrast media dose. This dose relationship was consistent across all BMI groups.

Key Words
Radiation reduction, visceral embolization, imaging technology

Introduction

A significant number of patients with significant gastrointestinal bleeding can be treated by angiography with selective embolization of the visceral artery branches. However, arterial embolization of visceral arteries requires sophisticated imaging, exposing both operators as well as patients to high radiation dose [1]. Moreover, in obese patients an exponential increase of ionizing radiation is required to assure proper image quality [2-4]. In consequence, concerns have been raised on the radiation exposure of patients and operators, and investigations have been prompted evaluating radiation dose amounts and strategies for possible dose reduction [5-8].

To address this major concern of radiation exposure, further developments from the imaging technology are required. AlluraClarity ([CIQ]; Philips Healthcare, Best, Netherlands) is intended to acquire equivalent image quality as the former AlluraXper system ([AX]; Philips Healthcare, Best, Netherlands) but for less radiation. CIQ has previously shown to significantly reduce radiation dose for various interventional cardiology-, interventional (neuro-) radiology and endovascular surgery procedures [9-16]. Despite the challenges of comparing different imaging technologies within different settings, a direct comparison of CIQ and AX was performed in several studies, showing no significant loss of image quality [9,13,15,16]. However, the CIQ technology is optimized for each specific acquisition protocol. Therefore, the promising results are not necessarily negotiable for all types of procedures and body locations. Inherently, achievable dose reduction for each type of procedure will be different as each requires a specific acquisition protocol.
The purpose of the present study was to evaluate the potential benefit of CIQ towards dose reduction and its impact on the physician working habits in patients undergoing visceral embolization therapy, since this is a subset of procedures known to necessitate high radiation doses [1,2].

Materials and Methods

Patients and Methods

This study evaluated a consecutive series of 239 patients (CIQ: n=100 [n=59 male, mean age: 70.6 years], AX: n=139 [n=71 male, mean age: 70.1 years]) undergoing visceral embolization therapy at a tertiary referral center. The indication for visceral embolization was related to gastrointestinal bleeding in all patients. Information on patients' demographics characteristics including weight and height (cm) and differentiated for CIQ and AX is provided in Table 1. Since physical conditions were shown to affect image acquisition and quality [2-4], body-mass-index (BMI [kg/m^2]) was evaluated. According to the BMI values, patients were categorized into three groups: group 1: BMI <25 kg/m^2, group 2: BMI ≥25 to <30 kg/m^2 and group 3: BMI ≥30 kg/m^2. As outlined in Table 1, there was a homogenous BMI distribution comparing the CIQ and AX groups.

To estimate the benefit of the novel CIQ technology, radiation dose recordings using CIQ were compared to radiation dose recordings using the former AX technology (control group). AX measurements were obtained from May 2011 to June 2013 and CIQ measurements after installation in July 2013 from July 2013 until April 2014, respectively. All procedures were performed following the radiation safety principle of *As Low As Reasonably Achievable* for both imaging technologies. Data collection and analysis was performed retrospectively. In line, the interventionists were not aware that this data is going to be evaluated at the time of procedure. Approval from our institutional IRB was obtained including a waiver of informed consent due to the retrospective nature of the evaluation. All data were collected in a Health Insurance Portability and Accountability Act compliant manner.

CIQ Technology and Measurements Obtained

CIQ is intended to acquire the equivalent image quality as AX, but for less radiation. This is achieved by an improved real-time image noise reduction algorithm as well as hardware optimization. The algorithm utilizes real-time automatic pixel shift, motion compensation, temporal- and spatial noise reduction to preserve image quality, while associated hardware reconfiguration is intended to reduce the entrance dose by adjusting and optimizing the full acquisition chain for different anatomic regions [9].

For the purpose of comparing the performance of the former AX with the novel CIQ technology, information on fluoroscopy time (minutes), total dose of iodinated contrast and AirKerma (Ka,r [milli Gray: mGy]) were evaluated. The Ka,r was calculated for the patient entrance reference point, which was considered the approximation of the patient's skin, located in the central X-ray beam and 15 cm from the isocenter towards the focal spot [17]. Fluoroscopy time and contrast usage served as indirect parameters for image quality. Similar amounts of contrast and fluoroscopy time were considered to indicate equivalent image quality comparing AX and CIQ. However, no direct comparison of image quality was performed.

Statistical Analysis

Categorical variables are presented as number and percentage and are compared using the Fisher's exact test. Continuous variables are presented as means ± standard

deviation (±SD) and 95% confidence interval (CI) where appropriate, and are compared using an independent t-test after checking for homogeneous distribution. This was done for the comparison of the total study and control groups, as well as for BMI subgroup analysis. A p-value <0.05 was considered statistically significant. Statistical calculations were performed using STATA software (STATA Statistics version 14.0, StataCorp, College Station, Texas).

Results

A total of 239 patients were undergoing visceral embolization procedures. As outlined in Table 1, patients did not differ by age, gender distribution and BMI when comparing the CIQ and AX cohorts. Procedural details are listed in Table 2 showing longer procedure times in CIQ patients (108.3±45.3 min versus 91.4±44.0 min, p=0.004, t-test). Figure 1 illustrates BMI subgroup analysis showing a difference in the BMI group 2 (117.0±7.1 min versus 86.8±5.0 min, p<0.001, t-test).

Fluoroscopy time (24.7±15.9 min versus 24.8±27.3 min, p=.96, t-test) and the use of contrast media volume (137.9±60.2 versus 141.4±62.1, p=.67, t-test) were similar when comparing the CIQ and AX groups and showing no significant differences in BMI subgroup analysis.

The overall Ka,r was lower in the CIQ group compared to the AX group: 1342.9±1080.1 mGy (95%-CI: 1128.6 to 1557.2) versus 2214.8±1826.8 (95%-CI: 1908.4 to 2421.2, p<.001, t-test).

Accordingly, mean Ka,r was 970.1±847.2 mGy (95%-CI: 702.7 to 1237.5) versus 1586.1±1335.0 mGy (95%-CI: 1241.2 to 1930.9) comparing CIQ versus AX (p=.003, t-test) in BMI group 1, 1484.7±1160.6 mGy (95%-CI: 1113.5 to 1855.9) versus 2170.1±1458.2 mGy (95%-CI: 1726.7 to 2613.4) in BMI group 2 (p=.02, t-test) and 1848.8±1128.0 mGy (95%-CI: 1305.1 to 2392.5) versus 3348.9±2395.7 mGy (95%-CI: 2526.0 to 4171.9) in BMI group 3 (p=.001, t-test), respectively (Figure 2).

Discussion

There has been a rapid growth of endovascular therapies necessitating radiation within the last decades [18,19]. In line, operators have been faced with continued exposure and increasing cumulative radiation dose exposure [18,19]. This development and its consequences are a major concern not only for patients but also for the operators involved in angiographic interventional settings [5,7,8,20,21]. As a result, efforts to effectively reduce radiation dose while maintaining the necessary level of image quality have become paramount [22]. However, specific procedures such as visceral interventions as well as patients with higher body weight and BMI require more radiation to maintain image quality [2]. Therefore, technical advancements are necessitated to reduce radiation for these patients and procedures. The present study showed an average dose reduction of 39.4% in patients treated with CIQ when compared to AX imaging technology and this finding held true for all BMI groups.

Despite the challenges of comparing different imaging technologies within different settings, CIQ was previously shown to reduce radiation dose for no significant loss of image quality when compared to AX [9,10,15,16]. However, Soderman et al. were the only one performing a 1:1 direct comparison of the image quality in an interventional neuroradiology setting [9]. In each patient imaging was obtained using the CIQ and AX technologies. The images were reviewed in a randomized and blinded manner by three neuroradiologists and thereby, no loss of image quality was observed but the CIQ images were acquired using 25% of the AX radiation dose, only.
Thereafter, multiple single center series evaluated the potential of CIQ in reducing radiation dose for various types of procedures. Overall, a radiation dose reduction of >40% was achieved in all [10-13,15,16]. However, there was a wide range of radiation dose reduction indicating that the benefit of CIQ varies according to the procedure type and patients' habitus.
In order to properly generalize and to compare both imaging technologies in this study, the assessment of fluoroscopy time and the amount of contrast media utilized served as indirect parameters to assess procedural complexity between the two groups. The relatively large number of patients in both groups is also important to help compare the groups. Fluoroscopy time and the amount of contrast media used were similar in both groups (Table 2). Therefore, we suggest that the procedural complexity was comparable as indicated by the fluoroscopy time and the amount of contrast used, which we account as objective parameters.

The present study has several limitations. First, the current analysis is based on a retrospective evaluation of a de-identified dataset. Therefore, it was not possible to review specific procedural protocols and angiograms. Nevertheless, the heterogeneous patient population and procedural complexity in this large study population allows for indirect comparison of the two imaging modalities. In addition, it was not possible to systematically compare the image quality of CIQ and AX technology.
Second, there were a variety of different visceral embolization procedures included within the present study limiting the interpretation of procedure time and radiation dose.

Conclusion

The present study demonstrated that radiation dose can be significantly reduced in patients undergoing visceral embolization procedures by the use of CIQ. As expected, the results show an increase in radiation dose correlating with patient size. Despite the variability of procedure complexity, a consistent dose reduction was identified across the range of patient BMI. The need to understand the amount of radiation dose reduction possible with new technological advances is important as we attempt to determine which changes are truly significant while maintaining image and procedural quality. Further study of these technological advances is warranted especially for different acquisition protocols as the number and complexity of angiographic interventional procedures continue to increase.

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None

Conflict of interest

Author #4 is a Member of the Advisory Board of Philips but having no direct conflict of interest to report with this study.
All other authors report neither financial nor industrials relationships nor a conflict of interest.

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Legends of Figures

Figure 1
Depiction of procedure and fluoroscopy times according to BMI categories.

Figure 2
Ka,r values for the three different BMI groups.

Table 1
Patients´ characteristics and demographics of 239 patients undergoing visceral embolization

	AX n=139	**CIQ n=100**	**p-Value**
Male, n (%)	71 (51.1)	59 (59.0)	.24
Age [years], mean (±SD)	70.1 (±16.3)	70.6 (±13.8)	.80
BMI [kg/m^2], mean (±SD)	26.4 (±7.1)	26.4 (±5.0)	.93
BMI group 1, n (%)	60 (43.2)	41 (41.0)	.79
BMI group 2, n (%)	44 (31.6)	40 (40.0)	.22
BMI group 3, n (%)	35 (25.2)	19 (19.0)	.28

AX: AlluraXper, CIQ: AlluraClarity, n: number, SD: standard deviation, kg: kilogramm, m: meter
BMI group 1: BMI <25 kg/m^2, BMI group 2: BMI ≥25 kg/m^2 and <30 kg/m^2, BMI group 3: BMI ≥30 kg/m^2

Table 2
Procedural details of 239 patients undergoing visceral embolization.

	AX n=139	**CIQ n=100**	**p-Value**
Procedure time [min], mean (±SD)	91.4 (±44.0)	108.3 (±45.3)	.004
Flouro time [min], mean (±SD)	24.8 (±27.3)	24.7 (±15.9)	.96
Contrast [cc], mean (±SD)	141.4 (±62.1)	137.9 (±60.2)	.67
Air Kerma [mGy], mean (±SD)	2214.8 (±1826.8)	1342.9 (±1080.2)	<.001
Air Kerma [mGy] PFM [min], mean (±SD)	103.2 (±65.6)	61.8 (±50.0)	<.001

AX: AlluraXper, CIQ: AlluraClarity, n: number, min: minutes, SD: standard deviation, cc: centiliter, mGy: mili Gray, PFM: per flouroscopic minute