Digital subtraction angiography during TIPS creation or revision: data on radiation exposure and image quality obtained using a standard and a low-dose acquisition protocol in a flat-panel detector-based system

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Purpose

Recently it has been showed that in many vascular and cardiological interventional procedures fluoroscopy contributes to a relatively small fraction of total dose area product (DAP) administered, with approximately 70% of the total DAP originated from the acquisition of digital subtraction angiography (DSA) runs, meaning that documentation needed significantly more radiation than the fluoroscopy-guided performance of the intervention itself.

Transjugular intrahepatic portosystemic shunt (TIPS) creation is considered as being one of the most radiation-intensive procedures in interventional radiology, since it often requires long fluoroscopy times and acquisition of multiple (at least two) detailed digital subtraction angiograms.

Our main aim was to determine whether the use of a low-dose acquisition protocol (LDP) in DSA acquired using a flat-panel based system during TIPS creation/revision results in significant reduction of patient radiation exposure and adequate image quality, as compared to a default reference standard-dose acquisition protocol (SDP).
Methods and materials

This prospective study was approved by our institutional review board.

An informed consent to the study and to the single procedure was obtained in all cases.

During TIPS and TIPS revision two angiographic runs were performed as routine, the first after portal system catheterization and the second after stent deployment or stent angioplasty.

17 consecutive adult patients (mean age 61.5 years±13.0 - mean body mass index 26.3±5.1 ) who underwent TIPS creation (n=11) or TIPS revision (n=6) from December 2013 to March 2014 were included.

Procedures were performed in an angiographic suite with a flat panel detector-based system (Innova 4100, General Electric Medical Systems, USA).

Constant field of view, object to image-detector, and source to image-receptor distance were maintained in each patient during the two angiographic runs.

The Receptor Dose Limited Plus (RDL plus) protocol was used as LDP, while the standard image quality (IQ standard) protocol was used as SDP.

RDL plus protocol minimizes dose by reducing the maximum kV output of the x-ray tube. This, coupled with the enhanced detective quantum efficiency (DQE) of the detector, lowers the receptor entrance dose levels and produces enhanced image contrast at the expense of increased noise.

In each patient the LDP and the SDP were used in a random order for the two runs, with each patient serving as his/her own control.

The same amount of contrast material and the same flow velocity was used in all angiographic runs.

A 4 images/second acquisition rate was always used in both angiographic runs.

The ratio of the DAP per image was calculated for each DSA run pair to determine the relative radiation dose reduction (DAP given in cGy.cm2).
DAP was measured with a dual channel DIAMENTOR M4-KDK DAP/Dose meter transmission ion chamber (PTW, Freiburg, Germany) fixed to the collimator with a valid calibration and quality control certificate checked every six months.

Procedural images stored in our PACS system were randomized and reviewed blindly by two interventional radiologists, different from the procedural operator.

Image quality was graded into Grades I, II, and III, with Grade I being 'inadequate for a successful procedural outcome', Grade II 'adequate with average image quality', and Grade III 'adequate with excellent image quality'.
Results

All angiographic runs acquired with the LDP and SDP were deemed to be of diagnostic image quality (Grade II in 55.9% of cases and Grade III in 44.1% of cases, kappa statistic of 0.65).

The use of LDP didn’t affect the procedural outcome since there was no instance where sub-optimal image quality necessitated repeat angiography.

The DAP per image in DSAs acquired with the LDP was always numerically inferior to DAP per image in the control acquisitions performed using the SDP.

The mean DAP per image with the SDP was 48.95 cGy.cm², while the mean DAP per image with the LDP was 12.14 cGy.cm².

This translates in a reduction of DAP per image by 75.24±5.7% (p<0.001) through use of the LDP.

As limitation of this study the two DSA runs compared were performed in two different steps of the procedure and this could have influenced the evaluation of the image quality.

We tried to avoid this bias using a random order for the two runs in our patients instead of performing the two DSA runs in the same step of the procedure requiring an overall increased number of DSA run with increased dose of contrast material and increasing the radiation exposure for the patient.
Table 1: DAP per image observed with DSA acquired using the SDP and LDP in patients undergoing TIPS creation and TIPS revision, together with percentage reduction of DAP per image obtained using the LDP. BMI: body mass index. TIPS-C: TIPS Creation. TIPS-R: TIPS Revision. SDP: standard-dose acquisition protocol. LDP: low-dose acquisition protocol.

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Fig. 1: 70 year old patient with chronic hepatitis C-related cirrhosis. TIPS was performed for refractory ascites. Doppler ultrasound showed evidence of TIPS dysfunction 18 months post TIPS creation. DSA done following TIPS-portal system catheterization using the SDP showed stenosis in the uncovered portion of the right hepatic vein, just cranial to the TIPS stent. Note is also made of stasis in the portal, splenic, and mesenteric veins (DAP per image 61.9 cGy.cm2).

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**Fig. 2:** DSA performed just after co-axial stent placement in the same patient as Figure 1 using the LDP showed good flow within the stent, with resolution of the portal, splenic, and mesenteric venous stasis. A slight increase in image noise can be observed, with no compromise in diagnostic image quality. (DAP per image 13.8 cGy.cm²).
Conclusion

In conclusion, particular attention has to be made to the possibility of using low dose DSA acquisition protocols in commercially available flat panel detector-based systems to obtain a significant decrease in patients’ radiation exposure originating from the acquisition of DSA runs, with good diagnostic image quality.

A comprehensive dose optimization strategy can be achieved through proper training of operators, medical physicists, and technicians.
References


