International Journal of Radiography Imaging & Radiation Therapy
IJRIRT, 1(1): 18-24
www.scitcentral.com

Original Research Article: Open Access

A Comparison of Radiation Exposure between CTA and DSA Examinations of Acute Gastrointestinal Bleed

Sheo Kumar[1*], Isha Garg[1], Prabhaker Mishra[2], Ashok Kumar[3], UC Ghoshal[4], HK Singh[1] and Preeti Tiwari[1]

*[*1]Department of Radiodiagnosis, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India*

[2]Department of Biostatistics and Health Informatics, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India

[3]Department of Surgical Gastroenterology, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India

4Department of Gastroenterology, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India.

Received June 15, 2018; Accepted July 20, 2018; Published January 23, 2019

ABSTRACT

Background: The number of CTA investigations is continuously increasing compared to the DSA investigations; there is little comparative dose information about the different imaging techniques. In the present study, we compared the patient radiation exposure resulting from diagnostic CTA and DSA examinations for acute gastrointestinal bleed.

Materials and methods: This was hospital based prospective study. A total of 80 cases of GI bleed were included in whom both CT angiography and Digital subtraction angiography was done. These patients were finally analyzed.

Results: There was good overall agreement (64/80, 85%, 95% CI=75.6-91.2) with Sensitivity (64/66, 97%, 95% CI=88.5-99.5) and specificity (4/14, 28.5%, 95% CI=1-58) of CTA as compared to DSA. Kappa coefficient (0.33, 95% CI=0.05-0.61, p=0.001) showing a significant fair absolute agreement between two modalities (CTA and DSA). Effective Radiation doses (mSv) of the triple phase was significantly high in CTA as compared to DSA (19.71 ± 1.50 vs. 1.56 ± 0.56, p<0.001).

Conclusion: Although CTA can be easily used as a diagnostic modality in cases of acute GI bleed and it has similar accuracy in localization as compared to DSA, easily available in hospital and requires less expertise than the DSA with no morbidity but effective radiation dose of CTA was approximately 12 times as compared with DSA which revealed that DSA is much better (quite low radiation) than CTA.

Keywords: Computed tomography angiography, Digital subtraction angiography, Acute gastrointestinal bleed, Radiation doses, Kappa coefficient

INTRODUCTION

Acute gastrointestinal (G.I) bleeding remains an important cause of emergency hospital admissions, with substantial related morbidity and mortality [1]. Upper GI bleeding (UGIB) is a relatively frequent and common problem [2]. Accurate and prompt diagnosis of the bleeding source is crucial because mortality can be as high as 40% if there is hemodynamic instability in patients [3]. It is crucial that patients are imaged while they are actively bleeding clinically to maximize detection capabilities [4]. There is a considerable controversy in regard to the best modality for initial diagnosis of acute G.I. tract bleeding. Diagnostic procedures for G.I. tract bleeding include endoscopy, CT angiography, catheter angiography, technetium (Tc)-99m red blood cell scintigraphy and combinations of these. Endoscopy, colonoscopy or sigmoidoscopy is currently considered the first-line diagnostic and therapeutic procedures of choice for both upper and lower G.I. bleeding.

CT angiography and DSA, both has crucial role in preprocedure evaluation of a patient with GI bleeding, as it provides clinically relevant information about the anatomic

Corresponding author: Dr. Sheo Kumar, Professor, Department of Radiodiagnosis, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow-226014, India, Tel: (0522)-2494569; 9450334047; E-mail: drsheokumar.radio@gmail.com

Citation: Kumar S, Garg I, Mishra P, Kumar A, Ghoshal UC, et al. (2019) A Comparison of Radiation Exposure between CTA and DSA Examinations of Acute Gastrointestinal Bleed. Int J Radiography Imaging Radiat Ther, 1(1): 18-24.

variation of the mesenteric vessels, the site of active GI bleeding and the vascular supply to the bleeding site [5]. CTA can detect flow rates as low as 0.3 ml/min in the animal model and appears to be as sensitive as DSA in clinical practice, with accuracy in localizing the site of hemorrhage approaching 100% [6]. Despite most of the detectable risk/benefit property of the CTA and DSA are almost same, DSA has one major advantage over the CTA as patient experience low radiation in former as compared to later [7,8].

Owing to the burgeoning application of radiological procedures involving radiation exposure, there is an emergent need for radiation dose reduction to avoid a reversal of the risk-benefit ratio associated with this imaging modality [9]. Radiation exposure is an accepted and necessary aspect of modern medical practice, but there may be over 100 deaths annually as a direct result of radiation use for diagnosis and treatment [10].

So while attending to the procedure and needs of the patient, the Interventional Radiology is placed in a unique role as the fluoroscopy supervisor overseeing the radiation protection for patients, self, staff and any trainees. Since radiation is an invisible threat in endovascular interventions, attention to protection may be challenging for the surgeon to understand and enforce [10].

The main risks to the subject undergoing a diagnostic x-ray based examination are due to stochastic effects which may result in cancer and genetic effects, which occur in the offspring of the irradiated subject. The probability of stochastic effects depends on the amount of absorbed dose. CT is a high-dose imaging modality, although doses are generally well below the threshold dose for the induction of deterministic effects [11,12]. As a result, the risk from CT radiation is that of carcinogenesis and the induction of genetic effects, which is best quantified by the ED [13,14]. Radiation exposure risks also need monitoring just as a surgeon monitors individual morbidity and mortality.

The absorbed dose is the energy absorbed per unit of mass and is measured in grays (Gy). The organ dose (or the distribution of dose in the organ) will largely determine the level of risk to that organ from the radiation. The effective dose, expressed in Sieverts (Sv), is used for dose distributions that are not homogeneous (which is always the case with CT); it is designed to be proportional to a genetics estimate of the overall harm to the patient caused by the radiation exposure. The effective dose allows for a rough comparison between different scenarios but provides only an approximate estimate of the true risk. For risk estimation, the dose absorbed by the organ is preferred quantity.

The radiation dose descriptor used in CT is the CT dose index or CTDI, integrates the radiation dose delivered both within and beyond the scan volume. CTDIvol is usually presented in milligrays (mGy). While it is not the dose to any specific patient, it is a standardized index of the average dose delivered from the scanning series. The term dose length product is used to represent the integrated dose and is equal to the average dose within the scanning volume (CTDI vol) times the total scan length (in cm). This parameter is also displayed on CT systems.

In DSA the only method of dose measurement required by the FDA is fluoroscopy time. Fluoroscopy equipment has devices to measure fluoroscopy time, but these timers are not ideal. They "provide a poor analogue of dose as they provide no information regarding x-ray field size or position. They do not account for differences in equipment, technique, or patient size." DAP is an example of this, and the poor estimation is seen when "a large dose delivered to a small skin area yields the same DAP as a small dose delivered to large skin area. Estimation of absorbed skin dose from DAP data has a potential error of at least 30% to 40%." The best measurement would be a method that shows cumulative radiation dose in real-time [15]. With careful pre-planning and continual intra-operative assessment, the radiation dose to the patient can be greatly reduced by keeping in mind that not every image needs to be perfect, rather just precise enough to effectively detect the problem, intervene and follow-up appropriately. Although the number of CTA examinations is continuously increasing compared to the DSA examinations; there is little comparative dose information about the different imaging techniques [16].

There is no study in the best of our knowledge in which the comparison of the radiation doses between the CTA and DSA has been studied. In the present study, we compared the patient radiation exposure resulting from diagnostic CTA and DSA examinations for acute gastrointestinal bleed. This study is likely to give insight and outline comparative benefits from the radiation exposure point of view.

OBJECTIVES

1. Comparisons of the complications and agreements in CT angiography and DSA modalities in investigations of acute gastrointestinal (GI) bleed.
2. Comparisons of the doses of X-ray radiation between CT angiography and DSA modalities in investigations of acute gastrointestinal (GI) bleed.

MATERIALS AND METHODS

This was a hospital based prospective cross-sectional study, conducted in the Department of Radiodiagnosis in association with the Department of Gastroenterology and Surgical Gastroenterology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow from January 2013 to December 2017 (5 years). A total of 80 cases of GI bleed were included in our study in whom both CT angiography and Digital subtraction angiography was done. These patients were finally analyzed.

DSA protocol

PHILIPS (ALLURA X PER RD 20, Netherlands) 3D DSA machine used to GI bleed performed from a common femoral artery access with the Seldinger technique. 5-F arterial sheath was secured in the common femoral artery. A bolus injection of heparin (50 IU/kg body weight) was given before the start of the procedure. Diagnostic angiograms of the celiac artery, SMA and IMA performed with the help of 5F SIM-1/RC catheter. Diagnostic Angiography performed with 30-35 mL of nonionic iodinated contrast material injected at a rate of 3-4 mL/s for celiac artery and SMA. For the inferior mesenteric artery, diagnostic angiography was performed with 15-20 mL of nonionic iodinated contrast material injected at 2-3 mL/s. Multiple projections were obtained in AP, lateral, right and left oblique view for the detection of pseudo aneurysm, AV fistula and active contrast leak. Super selective angiograms were taken with help of micro-catheter with slow and steady injection of the contrast. Angiographic findings were analyzed on workstation. Similarly CT image protocol used in the GI bleed diagnosis is given in the **Table 1.**

Table 1. CT Angiogram with parameters.

	NCCT	Arterial	Portal	Venous
Detector configuration	64 × 0.625 mm	64 × 0.625 mm	64 × 0.625 mm	64 × 0.625 mm
Section thickness	3 mm	1 mm	2 mm	2 mm
Section increment	1.5 mm	0.5 mm	1 mm	1 mm
Kvp	120	120	120	120
mAs/slice	300	250	250	250
Pitch	1.172	1.172	1.172	0.891
Rotation time	0.75 s	0.75 s	0.75 s	0.75 s
Field of view	350	350	350	350

Complication

Complication during CTA in the form of extravasation of contrast and allergic reaction were documented. Similarly complication during DSA likes Hematoma at the puncture site, catheter breakage and coil migration was documented.

Radiation dose monitoring

The X-ray radiation doses were monitored by placing the detector module of the MYDOSE mini (No.G9700, PDM-122-SH, Aloka, Japan) dosimeter (having calibration validity till 11th June 2018) near the patient's region of interest (ROI) during both (CTA and DSA) techniques **(Figures 1 and 2)**. Effort was made not to obscure the image's ROI while having all dose related information on direct X-ray beam field. To facilitate this during CTA the dosimeter was kept at the level of right groin and during the DSA the dosimeter was kept at the adjacent side of the abdomen and near to the region of study. Doses were noted in a cumulative dose mode from start and up to the end of the study.

Figure 1. Showing dosimeter used to measure to absorbed dose of radiation.

Inclusion criteria

The patients (≥ 18 years of age) with diagnosis of acute GI bleed who were referred to the Department of Radiology for CTA and DSA have been included in this study.

Exclusion criteria

Patients with contraindications to contrast, Pregnancy, Patient with variceal bleed have not been included in this study.

The patient was considered positive if any of the following characteristic was noted on imaging (both on CTA and DSA): Extravasation of contrast material into the bowel lumen was considered as the direct sign of active GI bleed. Indirect signs included detection of pseudo aneurysm, arteriovenous fistula, hyperemia and extravasation of contrast material into a confined space.

Sample size estimation

A sample size of 11 achieves 99.6% power to detect a mean of paired differences of 15.0 with an estimated standard deviation of differences of 6.0 at a significance level (alpha) of 0.001 using a two-sided paired t-test. Sample size was estimated using software MedCalc. Finally in this study, 80 patients have been included.

STATISTICAL ANALYSIS

Normality of the continuous data was tested and a variable was considered normal when standard deviation was less than half mean value. Paired samples t-test was used to test the mean difference in the effective radiation doses between CTA and DSA. McNemar chi-square test was used to compare the proportions between CTA and DSA. Measure of agreement (unweighted kappa) and its 95% Confidence Interval was calculated. Overall agreement, Sensitivity, Specificity of CTA was calculated as compared to the DSA which was considering as gold standard. A p-value<0.05 was considered as statistically significant. Data was analyzed using Statistical Package for Social Sciences, version 23 (SPSS-23, IBM, Chicago, USA) and MedCalc.

RESULTS

A total of 80 cases of GI bleed (male: n=54, 67.5%, female: n=26, 32.5%) were finally analyzed in whom both CT angiography and Digital subtraction angiography was done. Mean age of the patients was 40 ± 14.5 years with range of 19-71 years. Maximum number of patients were aged 21-40 years (n=38; 47.5%) followed by 41-60 years (n=34; 42.5%), <20 years (n=3, 3.8%) and ≥ 60 years (n=5, 6.25%). Out of total, 70 (87.5%) were showing UGI (upper gastrointestinal) bleeding while only 10 (12.5%) LGI (lower gastrointestinal) bleeding. Total 6 (7.5%) cases presented massive GI bleeding out of them, 5 (6.3%)) were UGI. Distribution of patients according to etiology showed that maximum 28 (35%) showing acute pancreatitis, followed by Post Cholecystectomy (12, 15%), Chronic Pancreatitis (6, 7.5%), Post Whipple's Pancreatico-Duodenectomy (6, 7.5%), BTA (6, 7.5%), PCD (4, 5.0%) and Others (18, 22.5%). Numbers of patients with pseudoaneurysm were 42 (52.5%), out of them, 40 (50%) patients each had one aneurysm, 1 (1.25%) patient had 2 aneurysm and another one patient (1.25%) had multiple micro-aneurysms.

Procedural complications in CTA and DSA

There were no procedural complication (extravasation of contrast and allergic reaction) noted to diagnose the GI bleed on CTA in any of the 80 cases. However, in 9 of the total 80 patients (11.3%), complication was noted during the DSA. The complications noted during the DSA were pseudoaneurysm at the puncture site (n=1), minor dissection of the vessel (n=2), catheter breakage (n=1), coil migration (n=3) and reflux of glue (n=1). There was a single case, in which rupture of the pseudoaneurysm and coil was migrated. None of these complications proved fatal to the patient.

Diagnostic accuracy and agreement between CTA and DSA

There was a good overall agreement between CTA and DSA (64/80, 85%, 95% CI=75.6-91.2) with Sensitivity and specificity of CTA (w.r.t. DSA) was (64/66, 97%, 95% CI=88.5-99.5) and (4/14, 28.5%, 95% CI=1-58), respectively. Kappa coefficient (0.33, 95% CI=0.05-0.61, p=0.001) showing a significant fair positive absolute agreement between two modalities (CTA and DSA) **(Table 2)**.

Radiation dose in CTA and DSA during diagnosis of acute GI bleed

Effective Radiation doses of the triple phase investigations were compared between CTA and DSA. Mean radiation doses (mSv) were 19.71 ± 1.50 (CTA) and 1.56 ± 0.56 (DSA), which difference was found to be statistically significant (p<0.001) **(Table 2** and **Figures 2 and 3)**.

Table 2. Diagnostic accuracy and effective radiation doses in triple phase between CTA and DSA.

	CT (N=80)	DSA (N=80)	P value
#Procedural complication (n (%))	0 (0%)	9 (11.3%)	**0.008**
#GI Bleed Detected	74 (92.5%)	66 (82.5%)	**0.043**
Overall Agreement	85% (95% CI=75.6-91.2)		**<0.001**
Absolute Agreement (Kappa coefficient)	κ=0.33 (95% CI=0.05-0.61)		**0.001**
Effective dose (mSv)			
$Mean ± SD	19.71 ± 1.50	1.56 ± 0.56	**<0.001**
Median	19.3	1.38	----
Min-Max	16.30-22.98	0.89-3.30	----

#McNamara Chi-square test used. $Paired samples t-test used, p<0.05 significant

DISCUSSION

The aim of the present study was to compare the radiation exposure between DSA and CTA for the diagnostic assessment. Except radiation, diagnostic accuracy of the CTA was also compared with DSA to see whether both modalities were comparable. Sensitivity (97%) and overall accuracy (85%) of the CTA was close to the DSA while specificity (28.5%) was quite low w.r.t. DSA, revealed that to detect the GI bleed in the patients, both methods were good.

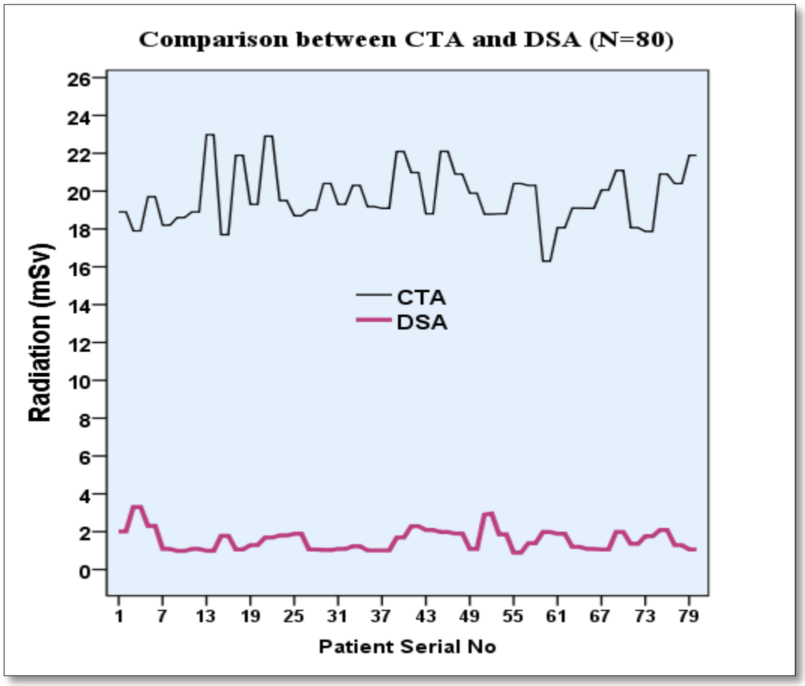

Figure 2. Line graph depicting comparison of radiation doses between CTA and DSA.

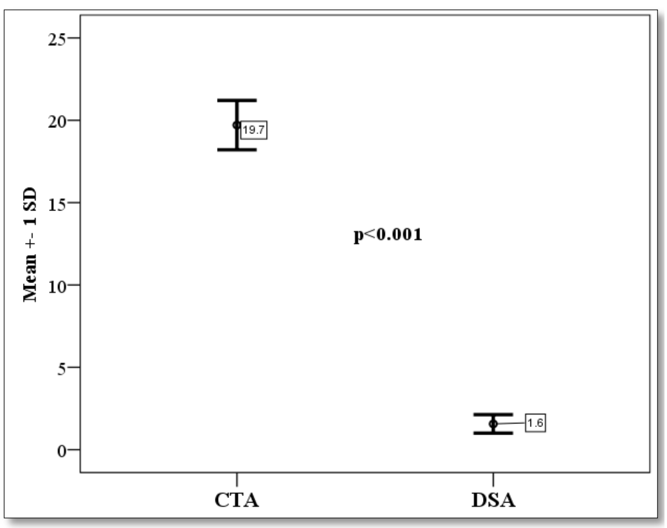

Figure 3. Error bar graph showing mean radiation doses between CTA and DSA.

Further we compared the patient radiation exposure resulting from CTA and DSA examinations. Mean scatter radiation dose (mSv) during triple phase CTA was significantly higher as compared to during the DSA (19.71 vs. 1.56, $p<0.001$). This was due to different kV and mA and multiple runs used during the study. The difference can also be explained from the fact that during triple phase CTA the patient has to be exposed thrice along with the different imaging parameters used in both types of investigations **(Figure 4)**. CTA is performed at kV ~120, mA ~245-300 while DSA is usually performed in a low fluoro setting, i.e., low tube current voltage and low milli-amperage (Kv ~85, mA ~10). Using mA value on lower side significantly reduces the radiation dose. CTA radiation dose increases in triple phase run compared to single run in DSA **(Figure 3)**.

As stated by Mulkens et al. [7], use of the tube current modulation and low tube voltage protocol can significantly reduce the radiation dose compared with standard dose.

Keeping in mind the concept of ALARA, every effort must be made to reduce radiation while performing CT angiography, to avoid unnecessary radiation to other body parts [8].

The present study showed that a CTA procedure for acute gastrointestinal bleed induces a higher risk compared with the same examination with DSA. The main reason is that absorbed doses were higher with the CTA procedure than with DSA. Knowledge of the radiation exposures and details of each imaging technique will help to optimize the imaging procedures.

The conversion factors we determined are a useful tool for clinicians and radiologists to estimate the effective doses of both imaging techniques and to compare the radiation exposure. Although CTA can be easily used as a diagnostic modality in cases of acute GI bleed and it has similar accuracy in localization as compared to DSA, easily available in hospital and requires less expertise than the

DSA with no morbidity but in terms of radiation, DSA is much better (quite low radiation) than CTA. In our experience, to diagnose acute GI bleed, conventional angiography with DSA techniques usually comes closest to that ideal.

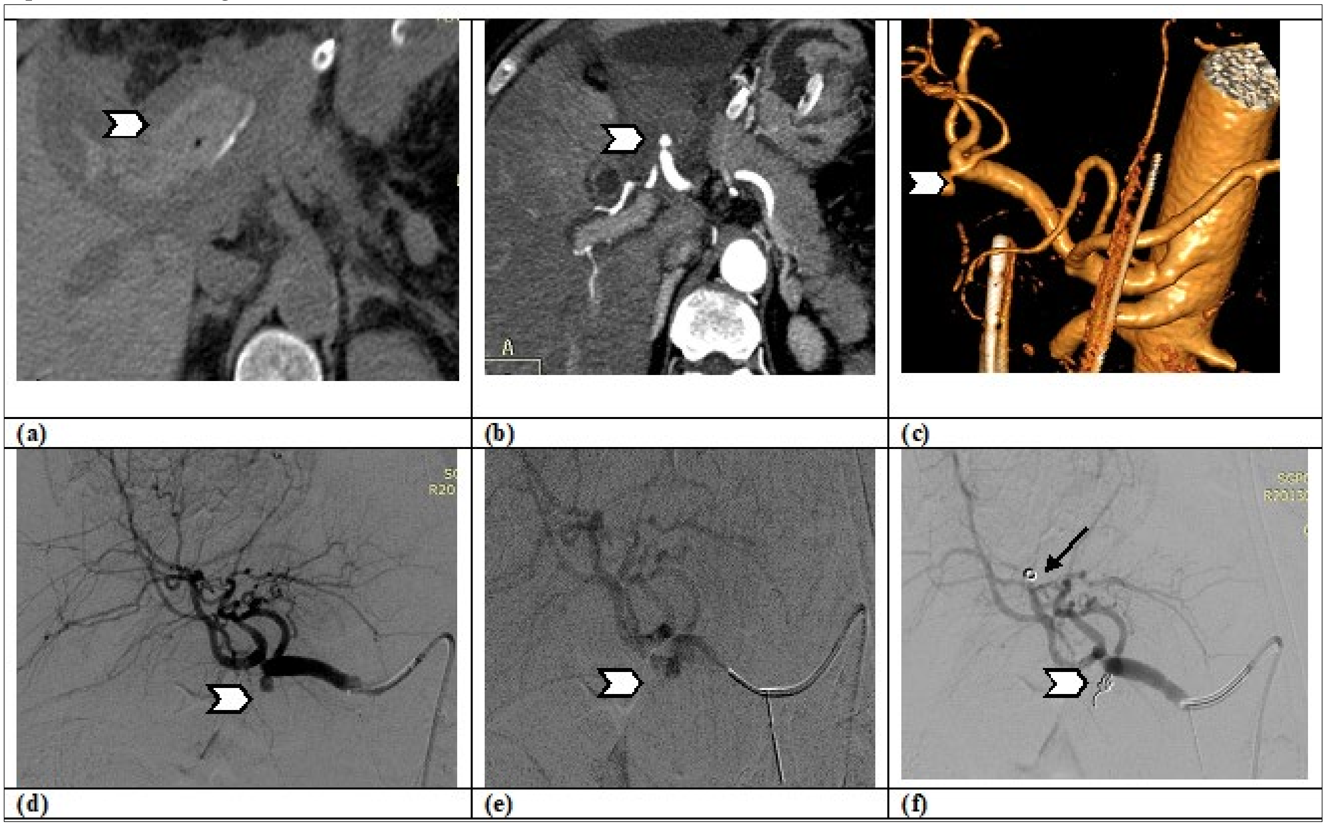

Figure 4. Showing a 55 year old female underwent Whipple's pancreaticoduodenectomy procedure for periampullary carcinoma. (a) NCCT image shows bleed (arrowhead) into the jejunum. (b) CTA MIP, MPR image shows GDA stump pseudoaneurysm (arrowhead) (c) VR image better shows the GDA stump pseudoaneurysm (arrowhead). (d) DSA image with selective cannulation of the common hepatic artery showing pseudo-aneurysm (arrowhead). (e) Rupture of the pseudoaneurysm (arrowhead) during the embolisation. (f) Post coil embolisation check angio shows no filling of the pseudo-aneurysm (arrowhead). There was coil in the right hepatic artery (black arrow).

CONCLUSION

The present study showed that radiation exposure with CTA examinations for the GI Bleeding produces a 12 times higher effective dose for the patient than the same examination performed with DSA. This study reveals that the absorbed doses during diagnostic CTA examinations are higher than those for DSA. The conversion factors determined in this study can be used to estimate the effective dose in CTA and DSA of GI Bleeding.

STRENGTH AND LIMITATIONS OF THIS STUDY

The present study is included in very few studies in which this kind of research has been done. Moderate small sample size is a limitation of this study. Interesting observations and trend was experienced in this study. It is recommended to conduct similar study on a larger sample size and various setting to explore the radiation doses in CTA and DSA modality.

REFERENCES

1. Geffroy Y, Rodallec MH, Boulay-Coletta I, Jullès MC, Ridereau-Zins C, et al. (2011) Multidetector CT angiography in acute gastrointestinal bleeding: Why, when and how. Radiographics 31: 35-46.
2. Storace M, Martin JG, Shah J, Bercu Z (2017) As an adjuvant tool for acute intra-abdominal or gastrointestinal bleeding. Tech Vasc Interventional Rad 20: 248-257.
3. Walsh RM, Anain P, Geisinger M, Vogt D, Mayes J, et al. (1999) Role of angiography and embolization for massive gastroduodenal hemorrhage. J Gastrointest Surg 3: 61-65.
4. Laing CJ, Tobias T, Rosenblum DI, Banker WL, Tseng L, et al. (2007) Acute gastrointestinal bleeding: emerging role of multidetector CT angiography and

review of current imaging techniques. Radiographics 27: 1055-1070.

5. Cherian MP, Mehta P, Kalyanpur TM, Hedgire SS, Narsinghpura KS (2009) Arterial interventions in gastrointestinal bleeding. Semin Intervent Radiol 26: 184-196.
6. Kuhle WG, Sheiman RG (2003) Detection of active colonic hemorrhage with use of helical CT: Findings in a swine model. Radiology 228: 743-752.
7. Mulkens TH, Daineffe S, De Wijngaert R, Bellinck P, Leonard A, et al. (2007) Urinary stone disease: Comparison of standard-dose and low-dose with 4D MDCT tube current modulation. Am J Roentol 188: 553-562.
8. American Society of Neuroradiology (ASNR) (2010) ACR-ASNR practice guideline for the performance and interpretation of cervicocerebral computed tomography angiography (CTA). Available from: https://www.asnr.org (Last accessed on May 11, 2018).
9. Rehani MM, Bongartz G, Kalender W (2000) Managing x-ray dose in computed tomography: ICRP special task force report. Ann ICRP 30: 7-45.
10. Erika R, Ketteler KR, Brown KR (2011) Radiation exposure in endovascular procedures. J Vasc Surg 53: 35S-38S.
11. (1990) Recommendations of the International Commission on radiological protection. Ann ICRP 21: 1-201.
12. Wagner LK, Eifel PJ, Geise RA (1994) Potential biological effects following high X-ray dose interventional procedures. J Vasc Interv Radiol 5: 71-84.
13. Huda W (1997) Radiation dosimetry in diagnostic radiology. AJR Am J Roentgenol 169: 1487-1488.
14. McCollough CH, Schueler BA (2000) Calculation of effective dose. Med Phys 27: 828-837.
15. Walsh SR, Cousins C, Tang TY, Gaunt ME, Boyle JR (2008) Ionizing radiation in endovascular interventions J Endovasc Ther 15: 680-687.
16. Manninen AL, Isokangas JM, Karttunen A, Siniluoto T, Nieminen MT (2012) A comparison of radiation exposure between diagnostic CTA and DSA examinations of cerebral and cervicocerebral vessels. Am J Neuroradiol 33: 1-5.