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Original Research Article

COMPARISION BETWEEN CT ANGIOGRAPHY AND DIGITAL SUBTRACTION ANGIOGRAPHY IN PATIENTS WITH HEMOPTYSIS PRIOR TO BRONCHIAL ARTERY EMBOLIZATION

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ABSTRACT

Background: Hemoptysis is a potentially life-threatening clinical condition requiring prompt identification of the bleeding source and appropriate management. Bronchial artery embolization (BAE) is the treatment of choice for controlling massive and recurrent hemoptysis. CT Angiography (CTA) is a non-invasive imaging modality that accurately delineates bronchial and non-bronchial systemic arteries, while Digital Subtraction Angiography (DSA) remains the gold standard during embolization. Comparing CTA with DSA helps determine the diagnostic accuracy of CTA and its utility in pre-procedural planning.

Aim: To compare CT angiography and Digital subtraction angiography in patients with hemoptysis prior to Bronchial artery embolization.

Materials and Methods: It was a Cross-sectional comparative study includes 45 patients. The study was conducted at Department ofRadiodiagnosis, NRI medical college and general hospital, Chinakakani over a period of 2 years.Patients with severe hemoptysis (blood loss >300ml/day) and Patients with recurrent bouts of moderate hemoptysis (3 or more bouts of blood loss of >100ml/day within a week) included.

Results: This cross-sectional comparative study at NRI Medical College included 45 patients with hemoptysis to compare CT Angiography (CTA) and Digital Subtraction Angiography (DSA) for identifying bronchial and non-bronchial systemic arteries before bronchial artery embolization. Most patients had pulmonary tuberculosis (68.89%), and moderate hemoptysis was most common (56%). DSA showed significantly higher detection of right bronchial arteries (91.1% vs. 73.3%) and non-bronchial systemic arteries compared with CTA. Overall, DSA provided better visualization and detailed anatomical information, making it more effective for planning bronchial artery embolization.

Conclusion: The study comparing CT Angiography (CTA) and Digital Subtraction Angiography (DSA) in patients with hemoptysis prior to bronchial artery embolization provides significant insights into the strengths and limitations of each imaging technique. The results highlight the superior efficacy of DSA in accurately identifying bronchial and non-bronchial systemic arteries, which is crucial for effective treatment planning and intervention.

Keywords: CT angiography, DSA, Hemoptysis, Bronchial arteries, Digital subtraction angiography

INTRODUCTION

Hemoptysis, defined as the expectoration of blood originating from the respiratory tract, poses a significant clinical challenge due to its potentially life-threatening nature and diverse aetiologies, ranging from benign conditions to serious underlying diseases such as bronchiectasis, lung cancer, and pulmonary vascular malformations.[1] Management strategies for hemoptysis include conservative measures, bronchoscopic interventions and surgical options. However, bronchial artery embolization (BAE) has gained prominence as a minimally invasive and effective therapeutic option for controlling hemoptysis, particularly in cases where bleeding persists despite initial treatments.[2]

Prior to performing BAE, precise localization of the bleeding source within the bronchial arterial system is critical for achieving successful outcomes. Digital subtraction angiography (DSA) has traditionally served as the gold standard imaging modality for this purpose, offering high spatial resolution and real-time imaging capabilities that enable direct visualization and selective catheterization of the culprit vessels.[3] Despite its diagnostic accuracy, DSA involves invasive arterial catheterization, which carries inherent risks such as vascular injury, contrast-induced nephropathy, and thromboembolic complications.[4]

In recent years, computed tomography angiography (CTA) has emerged as a promising non-invasive alternative to DSA. CTA utilizes rapid multidetector CT scanners to acquire high-resolution images of the pulmonary vasculature, providing detailed anatomical information and three-dimensional reconstructions without theneed for invasive catheterization.[5] Advancements in CT technology, including improved spatial resolution and reduced acquisition times, have enhanced the diagnostic utility of CTA in various vascular and pulmonary pathologies, including hemoptysis.[6]

Several studies have highlighted the diagnostic accuracy of CTA in identifying the source of hemoptysis, demonstrating comparable sensitivity and specificity to DSA in detecting bronchial artery abnormalities and vascular lesions.[7,8] Furthermore, CTA offers additional benefits such as the ability to evaluate surrounding lung parenchyma for underlying pulmonary conditions and a reduced procedural time compared to DSA.[9]

Despite these advantages, concerns regarding radiation exposure and contrastinduced nephropathy associated with CTA remain pertinent, especially in patients with compromised renal function or repeated imaging needs.[10] Additionally, the selection of the optimal imaging modality for guiding BAE in patients with hemoptysis requires careful consideration of factors such as patient-specific characteristics, institutional expertise, and resource availability.

This study aims to systematically compare the diagnostic performance of CT angiography and digital subtraction angiography in patients presenting with hemoptysis prior to bronchial artery embolization. By evaluating the sensitivity, specificity, and overall accuracy of both modalities, we seek to determine whether CTA can serve as a reliable substitute for DSA in this clinical setting. Additionally, procedural characteristics including image quality, procedural time, and radiation exposure will be assessed to provide a comprehensive evaluation of the feasibility and utility of each imaging technique.

Through this comparative analysis, we aim to contribute valuable insights into the optimal imaging approach for guiding bronchial artery embolization in patients with hemoptysis, ultimately improving clinical outcomes and patient care.

Aims & objectives

Aim

- To compare CT angiography and Digital subtraction angiography in patients with hemoptysis prior to Bronchial artery embolization.

Objectives

Primary Objective

- To compare the results of CT angiography and digital subtraction angiography in the depiction of bronchial and non-bronchial systemic arteries.

Secondary Objective

- To evaluate bronchial arteries and non-bronchial systemic arteries on CT angiography.
- To evaluate bronchial arteries and non-bronchial systemic arteries on DSA.
- To compare the results of CT angiography and digital subtraction angiography.

MATERIALS AND METHODS

Study area: Department of Radiodiagnosis, NRI medical college and general hospital, Chinakakani.
Study Period: 2 years
Sample size: 45
Sampling method: Convenient sampling
Inclusion criteria:

- Patients with severe hemoptysis (blood loss >300ml/day).
- Patients with recurrent bouts of moderate hemoptysis (3 or more bouts of blood loss of >100ml/day within a week).
- Patients with chronic recurrent small volume (<100ml/day) hemoptysis that interferes with patients lifestyle. Exclusion criteria
- Patient's refusal for Digital subtraction angiography.
- Time interval between CT angiography and Digital subtraction angiography more than 30 days.
- Patients with mild hemoptysis who can be medically managed.

- Patients in whom angiography is contraindicated (contrast allergy, renal impairment).
- Those who are at risk due to radiation exposure - pregnancy.

Ethical Considerations

Prior approval was obtained from the institutional ethics committee. All 45 patients included in the study were provided with detailed information about the study's nature, potential risks and benefits, and their right to withdraw at any time. Informed written consent was obtained from each participant before inclusion in the study.

Diagnostic Procedures

CT Angiography (CTA)

- All patients underwent CTA to visualize the bronchial and non-bronchial arteries.
- CTA findings were analyzed to assess the depiction of artery ostium and course.

Digital Subtraction Angiography (DSA)

- Following CTA, all patients underwent DSA, which is considered the gold standard for evaluating vascular anatomy and pathology.
- DSA findings were used as the reference standard for comparison with CTA findings. Statistical Analysis

Data Presentation:

- Continuous variables were presented as mean ± standard deviation (SD).
- Categorical variables were summarized as frequencies and percentages.

Statistical Tests:

- Parametric variables (e.g., age, blood loss volume) were compared between groups using Student's t-test.
- Non-parametric variables (e.g., categorical data such as presence of specific arteries) were analyzed using the chi-square test or Fisher's exact test where appropriate.
- Significance Level: A p value ≤ 0.05 was considered statistically significant.

Limitations

Limitations of the study included the inherent biases associated with convenience sampling and potential selection bias due to exclusion criteria.

RESULTS

Table 1: Age distribution among the study patients

Age Group	Frequency	%
14-30 years	9	20%
31-50 years	17	37.80%
52-70 years	18	40%
>70 years	1	2.20%
Meant SD		46.9±11.9%

The study's participant demographics were distributed across various age groups as follows: 20% were aged 14-30 years, 37.80% were aged 31-50 years, 40% were aged 51-70 years, and 2.20% were over 70 years old. The mean age of participants was 46.9 years, with a standard deviation of 11.1 years.

Table 2: Gender Distribution among the study patients

Gender	Frequency	%
Males	30	66.80%
Females	15	33.40%
Total	45	100%

In the current study out of 45 study patients, males comprising approximately twothirds (66.60%) and females approximately one-third (33.40%) of the total sample.

Table 3: History of lung disease among the study patients

History of lung disease	Frequency	%
H/O Pulmary TB	31	68.89%
Kiebsiella	2	4.44%
Bronchiectasis	6	13.3%
Aspergilloma	3	6.67%
Carcinoma lung	2	4.44%
Lung abscess	1	2.22%

In the current study, 31 individuals (68.89%) had a history of Pulmonary Tuberculosis (TB), 2 individuals (4.44%) had a history of Klebsiella infection, and 12 individuals (26.67%) reported no history of lung disease. These findings indicate a predominanthistory of Pulmonary TB among the participants, with a smaller proportion reporting Klebsiella infection and a minority having no recorded lung disease history.

Table 4: Grading of hemoptysis among the study patients

Hemoptysis	Frequency	%
Mild/chronic small	9	20%
Moderate	25	56%
Severe/profuse	11	24%

Among the study participants, hemoptysis, characterized by coughing up blood, exhibited varying degrees of severity: 20% reported mild or chronic small episodes, 56% experienced moderate symptoms, and 24% presented with severe or profuse hemoptysis. These findings highlight the spectrum of symptom severity within thecohort, providing essential insights into the clinical manifestation of hemoptysis among the subjects under investigation.

Table 5: Non-bronchial systematic arteries identified among the study patients

Arteries	Frequency	%
SA	21	46.67%
ICA	2	4.44%
IMA	5	11.11%
PA	2	4.44%
LTA	3	6.67%
SICA	5	11.11%

The study identified several **non-bronchial systemic arteries**. The **Subclavian Artery (SA)** was the most common (**46.67%**), followed by the **Internal Mammary Artery (IMA)** and **Superior Intercostal Artery (SICA)** at **11.11% each**. Other arteries included the **Lateral Thoracic Artery (6.67%)** and **Intercostal Artery (4.44%)**.

The varied distribution demonstrates the **complexity and anatomical variability** of systemic arterial supply. Accurate identification of these arteries is important for **personalized treatment planning, safe arterial navigation, and effective embolization**, while reducing the risk of complications.

Table 6: Bronchial Artery Embolization Procedure status among the study patients

Bronchial Artery Embolization	Frequncy	%
Done	41	91.10%
Not Done	4	8.90%

Among the study participants, Bronchial Artery Embolization (BAE) was implemented in 91.10% of cases, indicating widespread utilization of this therapeutic intervention.

This procedure, aimed at managing various clinical conditions, was not performed in 8.90% of the study sample.

Table 7: Distribution of Common Trunk Artery Origin for BA

Origin of common trunk artery	D3	D4	D5	D6
Right Bronchial Artery (RBA)	0	28	7	7
Left Bronchial Artery (LBA)	0	6	12	10

Right Bronchial Artery (RBA):
The RBA most commonly originates from a common trunk artery at vertebral level D4, observed in 28 cases. This finding suggests a predominant anatomical pattern that should be considered in diagnostic imaging and surgical planning.

Left Bronchial Artery (LBA):

In contrast to the RBA, the LBA shows a distribution where its origin at D5 (12 cases) is more frequent than at D4 (6 cases). This asymmetry in origins highlights anatomical variations that may influence surgical approaches and treatment outcomes.

Table 8: No. of Right bronchial artery detected per patient on CT angiography

No. of RBA detected per patient on CTA	Frequency	%
1	32	71.10%
2	1	2.22%

In the context of the study, the number of Right Bronchial Arteries (RBA) detected per patient on Computed Tomography Angiography (CTA) is summarized as follows:

- 71.10% of patients had 1 Right Bronchial Artery detected.
- 2.22% of patients had 2 Right Bronchial Arteries detected.

These findings provide insight into the anatomical variability of the Right Bronchial Arteries among the study participants as observed through CTA imaging, highlighting the predominant occurrence of a single artery and the less common occurrence of twoarteries per patient. Such details are crucial for understanding vascular anatomy variability and its implications for clinical management and intervention strategies.

Table 9: No of Left bronchial artery detected per patient on CT angiography

No. of LBA detected per patient on CTA	Frequency	%
1	19	42%
2	0	0.00%

In the current study, Computed Tomography Angiography (CTA) identified Left Bronchial Arteries (LBA) as follows:

• 42% of patients had 1 LBA detected.

• None of the patients had 2 LBA detected.

These findings provide detailed anatomical insights into the distribution of Left Bronchial Arteries among the study participants, emphasizing the prevalence of a single artery per patient. Such precise anatomical information is crucial for accurate diagnosis and effective planning of therapeutic interventions in clinical settings

Table 10: No of Right bronchial artery detected per patient on digital subtraction angiography

No of RBA Detected per patient on DSA	Frequency	%
1	40	88.9%
2	1	2.22%

Among the study participants:

• 88.9% of patients had 1 Right Bronchial Artery detected using DSA.

• 2.22% of patients had 2 Right Bronchial Arteries detected using DSA.

These findings illustrate the efficacy of Digital Subtraction Angiography in identifying the number of Right Bronchial Arteries per patient, highlighting that a significant majority had a single artery identified, with a minority showing two arteries. This precise imaging technique provides essential anatomical details necessary for accurate diagnosis and planning of interventional procedures in clinical practice.

Table 11: No of Left bronchial artery detected per patient on digital subtraction angiography

No of LBA detected per patient on DSA	Frequency	%
1	28	62.2%
2	0	0.00%

In the context of the study using Digital Subtraction Angiography (DSA) to detect Left Bronchial Arteries (LBA) per patient, the findings are summarized as follows:

• 62.2% of patients had 1 Left Bronchial Artery detected using DSA.

• None of the patients had 2 Left Bronchial Arteries detected using DSA.

These results highlight the efficacy of DSA in identifying the presence of Left Bronchial Arteries, with a majority of patients having one artery visualized per examination.

Table 12: Comparison of RBA Identification using CTA and DSA among The study patients

	RBA		Chi-square value	p-value
	Identified	Not Identified		
CTA	33(73.3%)	12(26.7%)	4.86	**0.02**
DSA	41(91.1%)	4(8.9%)		

The present study compared the efficacy of Computed Tomography Angiography (CTA) and Digital Subtraction Angiography (DSA) in identifying Right Bronchial Arteries (RBA) among participants:

• CTA identified RBAs in 73.3% of cases, with 26.7% not identified

• DSA identified RBAs in 91.1% of cases, with 8.9% not identified.

The results highlight a statistically significant disparity (i.e. Chi-square = 4.86, p = 0.02) in RBA identification between CTA and DSA, with DSA demonstrating notably superioreffectiveness in visualizing RBAs. These findings emphasize the potential advantage of DSA over CTA in clinical settings requiring precise vascular imaging.

Table 13: Comparison of LBA Identification using CTA and DSA among the study patients

	LBA		Chi-square value	p-value
	Identified	Not Identified		
CTA	19(42.2%)	26(47.8%)	3.607	**0.05**
DSA	28(62.2%)	17(37.8%)		

The present study compared the efficacy of Computed Tomography Angiography (CTA) and Digital Subtraction Angiography (DSA) in identifying Left Bronchial Arteries (LBA) among participants:

• CTA identified LBAs in 42.2% of cases, with 47.8% not identified (Chi-square = 3.607, p = 0.05).

• DSA identified LBAs in 62.2% of cases, with 37.8% not identified.

These results indicate a statistically significant difference in LBA identification between CTA and DSA, with DSA showing a higher rate of identification. The findings suggest that DSA may offer advantages over CTA in visualizing LBAs, emphasizing its potential utility in clinical scenarios requiring accurate vascular imaging.

Table 14: Comparison of RNBA Identification using CTA and DSA among the study patients

	R	NBSA	Chi-square value	p-value
	Identified	Not Identified		
CTA	15(33.33%)	30(66.67%)	3.665	**0.05**
DSA	24(53.3%)	21(46.7%)		

The current study compared the effectiveness of Computed Tomography Angiography (CTA) and Digital Subtraction Angiography (DSA) in identifying Right Non-Bronchial Systemic Arteries (RNBSA) among participants:

• CTA identified RNBSAs in 33.33% of cases, with 66.67% not identified (Chi square = 3.665, p = 0.05).

• DSA identified RNBSAs in 53.3% of cases, with 46.7% not identified.

These results show a significant difference in RNBSA identification between CTA and DSA, with DSA demonstrating a higher identification rate. This suggests that DSA may offer advantages over CTA for accurately visualizing RNBSAs in clinical practice, highlighting its potential in enhancing systemic arterial imaging precision.

Table 15: Comparison of LNBSA Identification using CTA and DSA among the study patients

	LNBSA		Chi-square value	p-value
	Identified	Not Identified		
CTA	4(8.88%)	41(91.22%)	3.92	**0.04**
DSA	11(24.4%)	34(75.6%)		

The current study compared the effectiveness of Computed Tomography Angiography (CTA) and Digital Subtraction Angiography (DSA) in identifying Left Non-Bronchial Systemic Arteries (LNBSA) among participants:

•CTA identified LNBSAs in 8.88% of cases, with 91.22% not identified (Chi square = 3.92, p = 0.04). DSA identified LNBSAs in 24.4% of cases, with 75.6% not identified.

These findings indicate a statistically significant difference in LNBSA identification between CTA and DSA, with DSA demonstrating a higher identification rate. This suggests that DSA may offer advantages over CTA in accurately visualizing LNBSAs in clinical practice, highlighting its potential for improving systemic arterial imaging precision

In the current study the most common ostium position identified for Right bronchial artery is between 9 ‘O’ clock and 10 ‘O’ clock position in 98% study patients.

In the current study the most common ostium position identified for left bronchial artery is between 11 ‘O’ clock and 1 ‘O’ clock position in 88% study patients.

Table 16: Diameters or thickness of the bronchial arteries

Diameter	RBA	LBA
Maximum diameter	3mm	2.8mm
Minimum diameter	1.9mm	1.7mm
Mean diameter	2.45mm	2.25mm

DISCUSSION

This study analyzed patient demographics, medical history, and the effectiveness of CTA and DSA in identifying bronchial arteries.

- **Age:** The mean age was 46.9 ± 11.1 years, with 77.8% aged 31–70 years. This is comparable to previous BAE studies, which mainly reported middle-aged patients.

- **Gender:** Males constituted 66.6% and females 33.4%, consistent with previous studies showing male predominance, possibly due to higher exposure to risk factors such as smoking and occupational hazards.
- **Lung Disease:** Pulmonary tuberculosis was the most common underlying condition (68.89%), followed by bronchiectasis (13.3%), aspergilloma (6.67%), and lung carcinoma (4.44%). The high prevalence of TB is consistent with findings from other TB-endemic regions.
- **Regional Differences:** TB prevalence was higher in this study compared with non-endemic regions, where bronchiectasis and malignancy are more common. This highlights the influence of regional epidemiology on the causes of hemoptysis.
- **Hemoptysis Severity:** Hemoptysis was mild in 20%, moderate in 56%, and severe in 24% of patients. Similar findings in previous studies show that moderate-to-severe hemoptysis is a major indication for BAE.
- **Non-Bronchial Systemic Arteries:** The **subclavian artery** was the most frequently identified non-bronchial systemic artery (46.67%). Identifying these vessels is important for accurate embolization and preventing complications such as spinal cord ischemia.
- **BAE Procedure:** BAE was performed in **91.1%** of cases, consistent with previous studies. Its high utilization reflects its effectiveness and importance as a potentially life-saving treatment for severe hemoptysis.
- **Bronchial Artery Origin:** The right bronchial artery (RBA) most commonly originated at the **D4 level**, while the left bronchial artery (LBA) most frequently originated at **D5**. The anatomical variability supports the need for detailed pre-procedural imaging.
- **CTA Detection:** CTA detected one RBA in **71.1%** and one LBA in **42%** of patients. It is useful for initial assessment but may have limitations in detecting multiple or complex arteries.
- **DSA Detection:** DSA detected one RBA in **88.9%** and one LBA in **62.2%** of patients. Its higher detection rate is attributed to better spatial resolution and dynamic imaging.
- **CTA vs DSA:** RBA identification was **73.3% with CTA vs. 91.1% with DSA**, while LBA identification was **42.2% vs. 62.2%**, respectively. Overall, **DSA demonstrated superior sensitivity and anatomical delineation**, making it preferable for detailed vascular mapping and planning BAE.
- **RNBSA Identification:** CTA detected right non-bronchial systemic arteries (RNBSAs) in **33.33%**, while DSA detected them in **53.3%**, showing better sensitivity of DSA.
- **LNBSA Identification:** CTA identified left non-bronchial systemic arteries (LNBSAs) in **8.88%**, compared with **24.4%** by DSA (**$p < 0.05$**). This demonstrates DSA's superior vascular visualization.
- **Ostium Position:** The RBA ostium was commonly located at **9–10 o'clock**, and the LBA at **11–1 o'clock**, consistent with previous anatomical studies and useful for catheter placement.
- **Artery Diameter:** Maximum diameters were **3 mm for RBA** and **2.8 mm for LBA**, comparable with previous studies.
- **Clinical Implications**
- **Demographics:** BAE is commonly required in middle-aged to older patients, with a male predominance.
- **Lung Disease:** The high prevalence of pulmonary TB highlights the importance of TB control and monitoring for hemoptysis.
- **Hemoptysis:** Moderate-to-severe hemoptysis requires timely intervention, with BAE being an effective treatment.
- **Imaging: DSA is superior to CTA** for detailed identification of bronchial and non-bronchial systemic arteries, helping achieve accurate embolization and reduce complications.

CONCLUSION

The study comparing CT Angiography (CTA) and Digital Subtraction Angiography (DSA) in patients with hemoptysis prior to bronchial artery embolization provides significant insights into the strengths and limitations of each imaging technique. The results highlight the superior efficacy of DSA in accurately identifying bronchial and non-bronchial systemic arteries, which is crucial for effective treatment planning and intervention.

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