ISSN: 2091-2331 (Print) 2091-234X (Online)

Journal of Nobel Medical College

Volume 13, Number 01, Issue 24, January-June 2024, 71-75

Original Article

Determinant of Bronchoarterial Ratio in a Patient Undergoing Computed Tomography Chest

Amrendra Kumar Mahato*[1], Alina Khatiwada [2], Saurav Poudel [1], Sailendra Kumar Mahato [3], Dipak Kumar Yadav [1], Namrata Dev [1]

[1]Department of Radiology, Nobel Medical College Teaching Hospital, Biratnagar, Nepal, [2]Department of Radiology, Norvic International Hospital, Kathmandu, Nepal, [3]Department of Radiology Chitwan Medical College & Teaching Hospital, Bharatpur, Nepal

Article Received: 28th March, 2024; Accepted: 7th June, 2024; Published: 30th June, 2024

DOI: https://doi.org/10.3126/jonmc.v13i1.68110

Abstract

Background

Respiratory diseases pose a significant challenge in Nepali clinical settings due to elevated smoking rates and environmental risks. This study explores the structural changes in conditions such as asthma, chronic obstructive pulmonary disease, and bronchiectasis, utilizing noninvasive multi-detector computed tomography to assess airway remodeling. Despite conflicting western literature on bronchoarterial ratios, this research emphasizes the importance of evaluating these ratios in the Nepalese context for predicting airway disease severity.

Materials and Methods

The cross-sectional study conducted at Nobel Medical College and Teaching Hospital involved 129 participants aged over 20 undergoing chest computed tomography. It aimed to measure the bronchoarterial ratio and investigate its associations with age, gender, smoking history, and altitude of residence. Bronchoarterial ratios was calculated using averaged short-axis diameters of the right apical and right posterior basal segmental bronchi, excluding the left lung due to motion artifacts.

Results

Analysis indicated a Mean Bronchoarterial Ratio of 0.823 (SD 0.151), with the apical and basal segment BARs at 0.832 (SD 0.148) and 0.814 (SD 0.153), respectively. Notably, individuals aged over 65 who were smokers exhibited a significant increase in BAR. Additionally, a higher altitude of residence demonstrated a significant correlation with the Bronchoarterial ratio in the apical lung segment.

Conclusion

This study provides valuable insights into the bronchoarterial ratio within the Nepalese population, considering age, gender, smoking history, and altitude of residence. The findings underscore the potential relevance of these ratios in conditions involving airway remodeling, contributing to the understanding of respiratory diseases in this specific demographic.

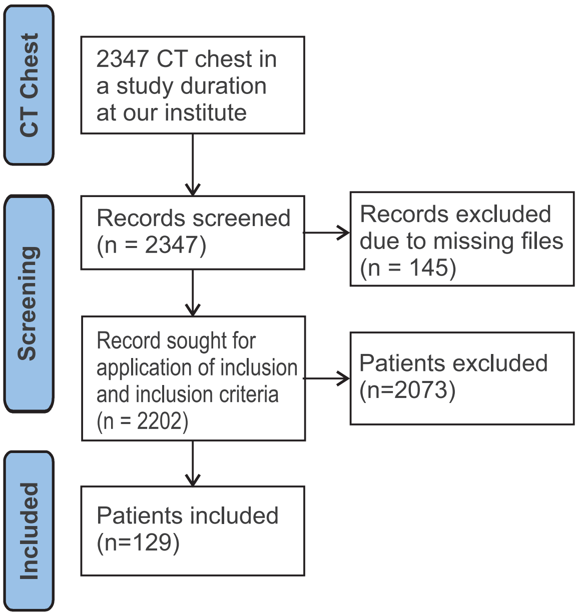
Keywords: *Airway Remodeling, Arteries, Bronchi, Respiratory tract disease*

***Corresponding Author:**
Dr. Amarendra Kumar Mahato
Lecturer
Email: abstray888@gmail.com
ORCID: https://orcid.org/0009-0000-3669-0849

Citation
Mahato AK , Khatiwada A, Poudel S, Mahato SK, Yadav DK, Namrata Dev N, Determinant of Bronchoarterial Ratio in a Patient UndergoingComputed Tomography Chest, JoNMC. 13:1 (2024) 71-75. DOI: https://doi.org/10.3126/jonmc.v13i1.68110

Introduction

Respiratory diseases encompass a spectrum of disorders affecting central and peripheral airways, marked by inflammation, structural changes, and airflow impediments [1, 2]. Chronic conditions like asthma, COPD, and bronchiectasis exhibit discernible airway



alterations due to remodeling, influencing their clinical course [3-5]. Airway inflammation and remodeling, linked to changes in diameter and adjacent vessel dimensions, necessitate standardized methodologies for assessment. Multidetector CT emerges as a noninvasive and accurate tool for diagnosing and monitoring airway diseases [6].

In Nepal, with a high prevalence of smoking and environmental risks, measuring bronchial-to-arterial (BAR) ratios becomes crucial in the evidence-based management of respiratory illnesses. The studies related to airway remodeling are still lacking in resource-lacking areas such as ours.

This study aims to quantify normal bronchial and pulmonary arterial diameter ratios, correlating BAR with age, gender, smoking, and altitude of residence to predict airway disease severity.

Materials and Methods

This is ananalytical cross-sectional study done at Nobel Medical College and Teaching Hospital in Biratnagar, Nepal from January 2023 to January 2024. The ethical clearance was taken from the internal review committee of the institute with reference number (Ref: IRC NMCTH 731/2023). Participants were explained about the study design and consent for the study was taken as written informed consent. The following formula is used to calculate the size of the required sample, $n = (z)^2 p (1–p) / d^2$, where, n = sample size, z = level of confidence according to the standard normal distribution (for a level of confidence of 95%, z = 1.96, for a level of confidence of 99%, z = 2.575), p = estimated proportion of the population that presents the characteristic (when unknown we use p = 0.5), d = tolerated margin of error (for example we want to know the real proportion within 10%). Therefore, to calculate a proportion with a 95% level of confidence and a margin of error of 9% we obtain, $n = (1.96)^2 / 4(0.09)^2 = 118$. However, we considered 129 of total patients in the study period.

Patients referred to the department of Radiology and Imaging at Nobel Medical College and Teaching Hospital (NMCTH) for chest CT scans were included in this study. The chest CT scans were conducted using a 128-slice MDCT Scanner (Siemens - Somatom Definition AS). The CT images of patients meeting the inclusion criteria were thoroughly evaluated. The sampling for this study took place at the department of Radiodiagnosis and Imaging at NMCTH over a duration spanning from January 2023 to January 2024. The sample size encompassed all eligible patients undergoing CT chest scans during this one-year duration who fulfilled the inclusion and exclusion criteria.

Inclusion criteria involved patients undergoing CT scans of the chest, specifically those with pulmonary pathology selectively affecting the left lung while sparing the right lung. Exclusion criteria comprised patients with a history of chest surgery, predefined pathologies such as pneumonia, bronchiectasis, COPD, pulmonary arterial hypertension, lung cancer involving the right lung, and asthma, as well as any other pathology hindering the measurement of the Bronchoarterial Ratio (BAR) in the apical and posterior basal segments of the right lung.

Operational definitions for variables in this study are outlined as follows: The Bronchoarterial ratio is a numerical ratio determined by dividing the diameter of the bronchial lumen by the diameter of its accompanying artery. Age is categorized into three groups: 20-40, 41-64, and ≥ 65. Smoking is defined by the number of pack years (>10) smoked by the patient, with airway remodeling pulmonary parenchymal changes becoming evident after a 10 pack-year history. A history of smoking exceeding 10 years is considered significant. High altitude is defined as living at an altitude greater than 1600m.

Chest CT scans of patients at the Department of Radiology, NMCTH, were assessed using a 128-slice helical CT scanner. Scans were performed in the supine position, in the cauda-cranial direction, with parameters set at 110 kV and 150 mAs, a modulation pitch of 1.0-1.5, and a slice collimation of 0.6 x 128 mm. If contrast was used, the volume ranged from 60-100 ml, with a control flow rate of 2.0-2.5 ml/s, and a scan delay of 20-35 seconds or bolus tracking.

The evaluation focused on the chosen region of interest (ROI) in the apical and posterior basal segments of the right lung, selected for their convenience in obtaining a tangential view of the bronchus and artery. The short-axis diameter of the segmental bronchus and accompanying artery was measured three times, and the mean values were calculated. The Bronchoarterial Ratio (BAR) was then determined, excluding the left lung due to motion artifacts.

Data were collected using a predefined form, analyzed with SPSS version 25, and expressed as mean ± standard deviation. Multivariate analysis assessed the relationship between BAR and age, sex, smoking, and altitude of living/working.

Results

A total of 129 patients were evaluated for BAR in the present study.Distribution according to age group is shown in table 1.

Table 1: Distribution of patients as per age group

Age Group	Number
20-40	39
41-64	52
> 65	38

In the present study, male comprises 55% (n=71). Most of the patient (94.57%, n=122) resides ata normal altitude. Only seven of them were living in high altitudes. The majority of the patients (75.97%, n=98) were smokers.

The average Bronchoarterialratioin the study population was 0.816 (SD=0.155) for males and 0.832 (SD=0.145) for females. Specifically, as shown in table 2, in the apical segment, the mean BAR was 0.824 (SD=0.158) for males and 0.843 (SD=0.136) for females. In the basal segment, the mean BAR was 0.808 (SD=0.154) for males and 0.821 (SD=0.153) for females. Statistical analysis revealed no significant difference in BAR between males and females, with P-values of 0.468 for the apical segment and 0.461 for the basal segment.

Table 2: Bronchoarterial ratio of the patients

Variable	N	Mean	Standard Deviation
Mean BAR in the apical segment	129	0.832	0.148
Mean BAR in the basal segment	129	0.814	0.153
Mean BAR	258	0.823	0.151

BAR: Bronchoarterial ratio

The Bronchoarterial ratio (BAR) in individuals residing at an altitude greater than 1600m was found to have a mean of 0.907 (SD = 0.137). Specifically, the mean BAR in the apical segment was 0.947 (SD = 0.136), while in the Postero-basal segment, it was 0.867 (SD = 0.136). A statistically significant difference in BAR was observed between individuals living at high altitudes and those at normal altitudes in the apical segment (P = 0.035). However, the BAR variation in the basal segment was statistically insignificant (P = 0.347).The average Bronchoarterial ratio (BAR) among smokers was 0.813 (SD= 0.141). Specifically, in the apical segment, the mean BAR was 0.865 (SD = 0.179), and in the basal segment, it was 0.822 (SD = 0.146). There was no statistically significant difference in BAR between smokers and non-smokers, with P-values of 0.166 for the apical segment and 0.171 for the basal segment.

There is a noteworthy association between the Bronchoarterial ratio (BAR) and the altitude of residence (P = 0.035) as shown in Table 3. However, no significant correlation was observed with age (P = 0.227) or smoking (P = 0.170).

Table 3: Multivariate analysis between altitude of residence, smoking, and age

Variables	Standardized coefficient (95% confidence interval)	P-value
Altitude of residence	0.185 (0.009-0.233)	0.035
Smoking	0.121 (0.018-0.102)	0.170
Age in years	0.106 (0.022-0.091)	0.227

A linear progression in the Bronchoarterial ratio (BAR) was evident with advancing age, registering values of 0.765 (SD = 0.111) for the age group 20-40 years, 0.788 (SD = 0.165) for 41-64 years, and 0.855 (SD = 0.109) for individuals aged ≥65 years (correlation coefficient [r] = 0.143 for the apical segment and r = 0.160 for the basal segment). Nevertheless, the observed increase in BAR did not attain statistical significance (P = 0.106 for the apical segment and P = 0.609 for the Posteriorbasal segment). There is no statistically significant variation observed between males and females in the 20-40-year age group (P = 0.629 for the apical segment and P = 0.357 for the basal segment). Additionally, no significant variation is detected in the Bronchoarterial ratio (BAR) between smokers and non-smokers in the same age group (P = 0.173 for the apical segment and P = 0.327 for the basal segment).

In the age group of 41-64 years, statistically insignificant variations were observed in the Bronchoarterial ratio (BAR) between males and females (P = 0.248 for the apical segment and P = 0.242 for the basal segment). Additionally, no significant variation was noted between smokers and non-smokers in the same age group (P = 0.215 for the apical segment and P = 0.449 for the basal segment). No variation in the Bronchoarterial ratio (BAR) was observed between males and females in the age group of ≥65 years (P = 0.646 for the apical segment and P = 0.885 for the basal segment). However, statistically significant variations were noted between smokers and non-smokers in the same age group (P = 0.001 for the apical segment and P = 0.003 for the basal segment).

Discussion

Respiratory diseases affecting the airways pose significant challenges in developed and developing nations. Airway remodeling is a prominent characteristic observed in various airway diseases, manifesting as alterations in the Bronchoarterial ratio. Although numerous tests exist to assess airway changes objectively, computed tomography (CT) stands out as the most readily available and accurate modality for evaluating the airway and respiratory system. However, limited research has been conducted on measuring the Bronchoarterial ratio, and the existing studies primarily involve the Caucasian population, with no such investigation found in Nepal.

In our study, nearly half of the participants belonged to the 40-64 age group. The analysis revealed an age-related increase in the Bronchoarterial ratio within our study population, indicating a positive correlation with advancing age. This trend could be attributed to the cumulative impact of insults to pulmonary anatomy over time. However, statistical significance regarding age was not attained, likely due to the study's small sample size. Moreover, no statistical distinction was observed between the apical and basal segments, aligning with the findings of Matsuoka et al [7], who reported similar Bronchoarterial ratios in these segments.

In contrast, a study by Kim et al [8] demonstrated considerable variation in the Bronchoarterial ratio between lobes and segments, suggesting limited value in assessing Bronchovascular bundles. Given the diffuse nature of many airway pathologies involving multiple lobes and segments, this may explain the absence of significant differences in Bronchoarterial ratios between the apical and posterior basal segments in our results. Diaz in their study concluded that BAR > 1 was fairly common and is a poor predictor in itself for airway remodeling. As 36% of the bronchus in never smokers had BAR > 1 [9].

The gender-based analysis did not reveal any statistical differences in Bronchoarterial ratios between males and females, and no previous studies provided normal values for these gender groups. Approximately 24% of the CT chest patients in our study were smokers, reflecting the prevalence of smoking in Nepal (32% in males and 15% in females). While no significant difference in Bronchoarterial ratios was observed between smokers and non-smokers aged 20-64 years, a significant disparity emerged in individuals aged 65 years and older. This contrasted with the findings of Matsuoka et al [7] and suggested that the combined effects of smoking and indoor pollution might contribute to increased Bronchoarterial ratios in elderly smokers. The increase in BAR was seen in the study by Diaz et. al [10], where they found the BAR to be significantly higher in the smoker group as compared to the non-smoker group.

Only a small fraction of the study participants reported a history of living or working at altitudes exceeding 1600m. Interestingly, individuals residing in high-altitude areas exhibited significantly higher Bronchoarterial ratios compared to those at lower altitudes, potentially linked to hypoxic vasoconstriction and bronchodilation at higher elevations. However, caution is warranted in interpreting these findings due to potential sampling bias stemming from the limited representation of high-altitude residents in the study. Notably, a prior study by Kim and Mueller et al, comparing Bronchoarterial ratios at sea level and high altitude, reported higher mean ratios for individuals living at higher altitudes, supporting our observed trend [8].

It is essential to acknowledge the study's limitation, as it was conducted on a small segment of the population visiting NMCTH. To substantiate and generalize our results, further investigations with a larger and more diverse sample size are warranted.

Conclusion

In conclusion, our study computed the mean Bronchoarterial ratio (BAR) in the right lung, stratifying the results by age, gender, smoking history, and place of residence within the observed population. With an increased mean BAR, these findings hold potential significance in the context of pathologies characterized by airway remodeling.

Acknowledgment: None

Conflict of interest: None

References

1. Boiselle PM, Ernst A, State-of-the-Art Imaging of the Central Airways, Respiration. 70:4 (2003) 383-94. DOI: 10.1159/000072902.
2. Okazawa M, Müller N, McNamara AE, Child S, Verburgt L, Paré PD, Human airway narrowing measured using high resolution computed tomography, Am JRespirCrit Care Med. 154:5 (1996) 1557-62. DOI: 10.1164/ajrccm.154.5.8912780
3. Boulet LP, Sterk PJ, A new series on airway remodelling, Eur Respir J.29:2 (2007) 231-2. DOI: 10.1183/09031936.00132406.
4. Postma DS, Timens W, Remodeling in asthma and chronic obstructive pulmonary disease, Proc Am Thorac Soc. 3:5 (2006) 434-9. DOI: 10.1513/pats.200601-006AW.
5. Bergeron C, Boulet LP, Structural changes in airway diseases: characteristics, mechanisms, consequences, and pharmacologic modulation, Chest. 129:4 (2006) 1068-87. DOI: 10.1378/ chest.129.4.1068.
6. Boiselle PM, Multislice helical CT of the central airways, Radiol Clin North Am. 41:3 (2003) 561-74. DOI: 10.1016/S0033-8389(03)00030-7.
7. Matsuoka S, Uchiyama K, Shima H, Ueno N, Oish S, Nojiri Y,Bronchoarterial ratio and bronchial wall thickness on high-resolution CT in asymptomatic subjects: correlation with age and smoking, AJR Am J Roentgenol. 180:2 (2003) 513-8. DOI: 10.2214/ajr.180.2.1800513.
8. Kim SJ, Im JG, Kim IO, Cho ST, Cha SH, Park KS, Kim DY, Normal bronchial and pulmonary arterial diameters measured by thin section CT, J Comput Assist Tomogr. 19:3 (1995) 365-9. DOI: 10.1097/00004728-199505000-00005.
9. Diaz AA, Young TP, Maselli DJ, Martinez CH, Maclean ES, Yen A, et. al, Bronchoarterial ratio in never-smokers adults: Implications for bronchial dilation definition, Respirology. 22:1 (2017) 108-113. DOI: 10.1111/resp.12875
10. Diaz AA, Young TP, Maselli DJ, Martinez CH, Gill R, Nardelli P, et. al, Quantitative CT Measures of Bronchiectasis in Smokers, Chest. 151:6 (2017) 1255-1262. DOI: 10.1016/j.chest.2016.11.024