Diagnostic efficiency of adropin as a preliminary test to exclude acute pulmonary embolism: a prospective study

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Abstract

Background: This study aims to investigate the efficiency of adropin as a biomarker to exclude the diagnosis of acute pulmonary embolism.

Methods: Patients admitted to the emergency department of a tertiary health center (a university hospital) between August 2019 and August 2020 and diagnosed with pulmonary embolism were included in this prospective cohort study. The amount of serum adropin was determined in patients with pulmonary embolism (who were diagnosed using computerized tomography pulmonary angiography) and compared with healthy volunteers.

Results: There were 57 participants in the study (28 controls and 29 PE patients). The mean value of the adropin level in the pulmonary embolism group was 187.33 ± 62.40 pg/ml which is significantly lower than the control group (524.06 ± 421.68 pg/ml) ($p < 0.001$). When the optimal adropin cut-off value was 213.78 pg/ml, the likelihood ratio of the adropin test was 3.4, and the sensitivity of the adropin test at this value was 82% with specificity of 75% (95% CI; AUC: 0.821).

Conclusion: The adropin test can be used to exclude the diagnosis of acute pulmonary embolism in the emergency department. However, more research is required to verify and support the generalizability of our study results.

Background

Acute pulmonary embolism (PE) occurs due to a sudden obliteration of pulmonary arteries, which results from a thrombus ascending up the bloodstream from the deep leg veins [1, 2]. The disorder presents with frequent symptoms of sudden dyspnea, stinging chest pain, tachycardia, cyanosis, hemoptysis, and occasional lower extremity swelling with pain [2]. However, the condition is hard to diagnose owing to a lack of specific symptoms and clinical signs. Although PE is an acute life-threatening condition, it is potentially reversible. Therefore, linked with the development of effective thrombolytic treatments, an early and accurate diagnosis of PE is of the utmost importance.

The gold standard method for the diagnosis of PE is pulmonary angiography, whereas computerized tomography pulmonary angiography (CTPA), which provides similar diagnostic accuracy, is preferred in clinical settings [3]. However, the clinical application for both of the above-mentioned methods has disadvantage due to the associated radiation exposure, the use of radio-opaque materials, and the need for a skilled operator. These disadvantages of radiographic imaging summon up the importance of using biomarkers and laboratory facilities for diagnostic purposes. Recent advances in biotechnology have engendered the detection of new biomarkers in the laboratory, such as adropin.

Adropin is a polypeptide comprising a total of 76 amino acids, including the first 33 amino acids of the signal peptide, and has a molecular weight of 4999 Da [4, 5]. It is a small polypeptide plays essentially an important role in inflammation and some metabolic events [6]. Few studies have suggested the use of

adropin as a biomarker in patients suffering from conditions with cellular hypoxia and destruction, such as acute myocardial infarction [7, 8].

This study aimed to determine the diagnostic efficiency of adropin to exclude the diagnosis of acute PE, which is characterized by cellular ischemia and necrosis due to obstruction from the thrombus.

Methods

Ethics approval and informed consent

Ethical approval for this study was obtained from the Non-Invasive Clinical Research Ethics Committee of a local university (registration number – 2019.185.10.06). Written informed consent was obtained from all patients and healthy volunteers who agreed to participate. The reporting of this study conforms to the STARD guidelines.

Study design and participants

This prospective study was conducted in a university tertiary care hospital. Patients above the age of 18 years showing up at the emergency department (ED) between August 1, 2019 and August 1, 2020, and diagnosed with pulmonary embolism based on detection of a thrombus in CTPA were included in this study. Patients who were pregnant, had a history of malignancy (due to the uncertainty of how adropin level is affected by inflammation), were without CTPA imaging, were forwarded to our center with a confirmed diagnosis, and those who required cardiopulmonary resuscitation were excluded from the study. Healthy volunteers of similar age and gender were selected for the comparison group.

When the diagnosis of PE was confirmed, a blood sample of 5 ml was drawn from all included patients and put in red capped tubes. The blood tubes were then centrifuged at 3000 rpm for 15 minutes to separate the serum. The serum samples obtained were kept at -80°C. After enough sample size was reached, samples were brought to room temperature on the day of analysis, and serum adropin levels was analyzed using the enzyme-linked immune sorbent assay (ELISA) method. Commercially available kits from Sino Gene Clon Biotech Co., Ltd. (catalog no: SG-11594) were used for the study; the kits have intra-assay and inter-assay CV values of < 8% and < 10%, respectively.

CTPA imaging was used as the reference standard in this study owing to the similarity of CTPA image results with pulmonary angiography and the ease of access to CTPA in the ED. The imaging was done using GE Bright Speed model 16 detector, and Mx 0.8 cc/kg contrast matter was applied under a pressure of 4 psi.

Additionally, age, sex, presenting complaint, the Geneva and the Wells' probability category score, bedside trans-thoracic echocardiography (TTE) findings, D-dimer, CRP levels, high-sensitive troponin and arterial blood gas analysis for all patients were obtained and saved in their case report forms.

The laboratory technician evaluating the adropin test was not informed of the final diagnosis of the patients, clinic findings and the CTPA results. The physician assigned to diagnosing the patients in the ED and evaluating the CTPA images had not been informed by the adropin levels, which were not yet studied.

To evaluate the efficacy of adropin, the blood samples from diagnosed PE patients were compared to healthy volunteers with no active complaints and without any history of chronic disease. The treatment planned for any patient was not changed or delayed during the conduct of the study.

Statistical analyses

Statistical analyses were performed using Statistical Program for the Social Sciences version 18.0 (IBM Inc.) and Analyse-it (Analyse-it Software Ltd). The Kolmogorov-Smirnov test was used to assessing the normality of distribution of the adropin levels and PE parameters, and Student's t-test was used to comparing the PE and control groups. Pearson's chi-squared test was used to determining the relationship between gender and PE variables, age and PE variables. Continuous variables were expressed as either mean ± Standard deviation or median (min-max), and the Mann-Whitney U test was used to determining relationships between them. Categorical values were expressed as absolute numbers and percentages. A value of $p < 0.05$ was considered statistically significant. Receiver Operating Characteristic (ROC) analysis was specified with 95% confidence interval (95%CI) and Area Under Curve (AUC) values. Cut off was determined according to the highest likelihood ratio.

Results

In this study, 29 PE patients (average age = 64.48 ± 12.73 years) and 28 healthy controls (average age = 61.69 ± 27.22 years) were included. In the PE group, 19 (65.5%) were females and 10 (34.5%) were males, while the control group had 12 females and 16 males. There was no statistically significant difference in age values and sex between the PE and control groups (Table 1).

Table 1
Comparison of the demographic characteristics of the embolism and control group

	n(%)	p
Sex		0.07
PE group (Female)	19(65.5%)	
Control group (Female)	12(42.8%)	
Age		0.12
PE group	64.48 ± 12.73	
Control group	61.69 ± 27.22	
PE; pulmonary embolism		

The presenting complaints on admission for the 29 patients in the PE group were dyspnea (n = 17, 58.6%), chest pain (n = 8, 27.8%), weakness (n = 2, 6.8%), tachycardia (n = 1, 3.4%), back pain (n = 1, 3.4%), and cough and hemoptysis (n = 1, 3.4%) (Table 2). In the PE group, the median value for D-dimer was 5.92 mg/L (0.81-35), median CRP levels were 39.5 mg/L (2.75-239), and median troponin value was 55 ng/L (4-231). Further, there was no correlation between adropin and D-dimer levels, CRP levels, and troponin levels (p=0.2, p=0.2, p=0.2, respectively). The laboratory results for the PE patients are given in table 3.

Table 2
Complaints of PE group admission to the emergency room

Complaints	n(%)
Dyspnea	17 (%58.6)
Chest pain	8 (%27.8)
Weakness	2 (%6.8)
Tachycardia	1 (%3.4)
Backpain	2 (%6.8)
Syncope	1 (%3.4)
Cough	1 (%3.4)
Hemoptysis	1 (%3.4)
Fever	1 (%3.4)
Epileptic seizure	1 (%3.4)
PE; pulmonary embolism	

Table 3
Laboratory findings of the PE group and additional adropin level of control group

Tests	Mean ± Std
D-dimer mg/L	9.64 ± 9.95
CRP mg/L	67.70 ± 64.38
Troponin ng/L	54.00 ± 45.39
Urea mg/dL	46.04 ± 29.01
Creatinine mg/dL	0.89 ± 0.25
WBC 10^3/ uL	11.03 ± 3.78
Hg g/dL	12.45 ± 2.17
Platelet 10^3/ uL	224.75 ± 87.03
Ph log[H+]-	7.45 ± 0.05
PO2mmHg	69.81 ± 23.83
PCO2mmHg	35.12 ± 8.70
Pt sn	13.97 ± 2.68
Aptt sn	23.92 ± 3.50
INR ınr	1.21 ± 0.24
PE; pulmonary embolism, WBC; white blood cell, INR; international normalized ratio	

Among the 29 PE patients, 3 (10.3%) were in the low-risk group, 20 (69%) were in the medium-risk group, and 6 (20.7%) were in the high-risk group according to the Genova scoring system. The correlation between adropin levels and Genova score was also statistically non-significant ($p = 0.5$). When the same patients were analyzed using the Wells' scoring system, 2 of them (6.9%) were at low risk, 25(86.2%) were at medium risk, and 2 (6.9%) were at high risk. The correlation between scoring systems – adropin and D-dimer levels were also non-significant ($p > 0.05$, in all groups) (Table 4).

Table 4
Adropin and d-dimer levels according to scoring systems groups in patients with PE

Tests	**Genova risk categorization**			
	Low risk	Medium risk	High risk	Between all risk categories
adropin	143,34 ± 35,04	189,27 ± 66,96	231,96 ± 97,53	p > 0,05
d-dimer	10,55 ± 0,43	9,47 ± 9,96	9,71 ± 12,54	p > 0,05
	Wells risk categorization			
	Low risk	Medium risk	High risk	Between all risk categories
adropin	177,09 ± 8,87	192,62 ± 77,16	218,79 ± 84,75	p > 0,05
d-dimer	3,0 ± 0	10,51 ± 10,48	5,16 ± 3,90	p > 0,05
PE; pulmonary embolism				

Among the TTE findings; right ventricle/left ventricle diameter ratio (RV/LV) was below 0.9 in 9 (15.8%) of the PE cases. Right ventricle wall thickness was measured from the same points in all cases as standard and RVWT was less than 5 mm in 5 (17.2%) patients, 5 mm in 10 (34.5%) patients, and greater than 5 mm in 14 (48.3%) PE patients. Pulmonary arterial wedge pressure (PAWP) in 13 patients was below 15 mmHg, in 6 patients it was between 15-30 mmHg, and in 10 patients it was 30 mmHg and above. The RV/LV ratio was below 0.9 in the entire control group. In addition, while the RVWD value of 4 participants was 5 mm, it was measured below 5 mm in 24 participants. Again, the PAWP value was measured below 30 mmHg in the entire control group (Table 5).

Both the PE and control groups had normal distribution in terms of adropin levels (Fig. 1). The mean value of adropin level in the PE group was 187.33 ± 62.40 pg/ml, compared to 524.06 ± 421.68 pg/ml for the control group. The adropin level of the PE group was found to be significantly lower than that of the control group ($p \leq 0.001$) (Table 5).

Table 5
Comparison of adropin values and TTE findings between PE and control group

	Mean ± std	P value
Adropin (PE group) pg/ml	187.33 ± 62.40	< 0,001
Adropin (control group) pg/ml	524.06 ± 421.68	
RV/LV ratio (PE group) cm	0,97 ± 0,17	< 0,001
RV/LV ratio (control group) cm	0,7 ± 0,08	
RVWT (PE group) mm	5,93 ± 1,79	< 0,001
RVWT (control group) mm	3,71 ± 0,71	
PAWP (PE group) mmHg	26,68 ± 21,10	< 0,001
PAWP (control group) mmHg	14,32 ± 2,22	

TTE: trans thoracic echocardiography, PE: pulmonary embolism, RV/LV: right ventricle/left ventricle, RVWT: Right ventricle wall thickness, PAWP: Pulmonary arterial wedge pressure

When the optimal adropin cut-off value was 213.78 pg/ml, the likelihood ratio of the adropin test was 3.4, and the sensitivity of the adropin test at this value was 82% with specificity of 75% (95% CI; AUC: 0.821). Further, the highest likelihood ratio obtained was 13.5, where the cut-off value was 304 pg/ml, the sensitivity of the test was 46%, and the specificity of the test was 96% (95%CI, AUC: 0.821) (Fig. 2).

After collecting the data sample size calculation was performed and the power of the study was defined with 29 patients' group and 28 control group. The effect size calculated on the data of the specified patients was determined as 0.7985439. When α error was accepted 0.05, the power of the study was calculated as 84%.

Discussion

To the best of our knowledge, this is the first study to assess the adropin as a preliminary test of acute pulmonary embolism. This study investigates the efficiency of adropin as a biomarker for excluding the diagnosis of acute PE in emergency department. Unlike D-dimer serum adropin levels have been indicated to decrease in multiple scenarios and can be evaluated as potential biomarkers in conditions such as diabetes mellitus, arterial hypertension, obesity, sleep apnea syndrome, and even osteoarthritis of the knees [9–12].

The increased awareness about various venous thromboembolic diseases in recent guidelines, supplemented essentially with an increased availability of non-invasive imaging tests such as CTPA, encouraged clinicians to suspect PE more frequently and start a diagnostic study to confirm the diagnosis at an early stage [3]. But the cost of unnecessary imaging and the desire to avoid the negative

effects of radiation, while evaluating non-invasive diagnostic strategies for PE in recent times, it is suggested that to exclude PE safely in the present patient population who has a rather low pre-test possibility of having the disease [13]. On the contrary, it is also emphasized that a positive test should have sufficient specificity to determine the indication for treatment, which is anticoagulant treatment in the case of PE [13].

In the ESC 2019 pulmonary embolism guideline; When PE is suspected at high risk in a hemodynamically unstable patient, bedside TTE or CTPA is recommended for diagnosis, depending on availability and clinical conditions [14]. The study that the guide refers to while making this prioritization was shared by Kucher et al in 2003. In this study, it was stated that time-consuming imaging tests that increase the risk of sudden death and delay the initiation of reperfusion therapy can be avoided in patients with suspected pulmonary embolism with shock findings, and that TTE is a highly specific imaging modality that allows treatment decisions for pulmonary embolism in the presence of right ventricle dilatation and systolic dysfunction [15]. In the study of Kim et al. has been stated that TTE has a critical importance in hemodynamic evaluation, and it may be useful in risk stratification, determination of therapeutic strategy, clinical decision making or evaluation of prognosis in PE [16]. In our study, bedside TTE was applied to all patients in the emergency department. We also think that TTE has a critical importance in hemodynamically unstable high-risk patients with suspected PE and may help in time-critical decision making.

In the ESC 2019 pulmonary embolism guideline; the presence of hemodynamic stability, it is recommended to use validated criteria for the diagnosis of PE [14]. Stable patients were triaged again for CTPA imaging preference based on clinical risk and D-dimer level [14]. The guideline states that D-dimer measurement is recommended in emergency department patients with low or moderate clinical probability to reduce the need for unnecessary imaging and radiation and states that it rules out pulmonary embolism in 30% of outpatients [14, 17–19] However, it is added that D-dimer should not be measured in high clinical probability group, emphasizing that false negative results are reported in pulmonary embolism patients [14, 20]. In our study, D-dimer levels with standard cut-off values were measured and clinical risk classification was performed in all suspected patients with stable hemodynamics. We also think that applying a triage according to clinical probability and D-dimer result instead of direct CTPA in patients with suspected low and intermediate risk pulmonary embolism may reduce unnecessary imaging.

Lovren F et al. stated that adropin inhibits tumor necrosis factor α-induced apoptosis and promotes migration, proliferation, and permeability in human umbilical vein endothelial cells with increasing the expression of endothelial nitric oxide synthase [21].

Sato et al. stated that according to the results of their study provide insight into the potential use of adropin to expand a therapeutic window in the prevention of atherosclerosis and they added the development of adropin analogs and receptor agonists may serve as potential therapeutic targets in atherosclerosis and its related diseases [22].

Kaluzna M et al. reported that adropin levels did not alter significantly during hemodialysis [23], and adropin was described as a potential candidate marker for cardiac dysfunction in patients undergoing hemodialysis. Additionally, Maciorkowska M et al. confirmed a negative correlation of adropin with progression of kidney failure [9].

In our results, there is no acute or chronic kidney failure in the PE group patients, which may have become a contraindication for using contrast substances in these patients. However, in the future with increasing evidence when patients with limited kidney functions are suspected to develop acute PE, serum adropin may be a useful alternative of D-dimer.

But it is not known exactly how adropin levels are affected by various systemic and non-systemic diseases. So, higher adropin levels may be beneficial for excluding the pathology rather than associating lower adropin levels to diagnosis.

Limitations

First, there is a rather small sample size so results and conclusion should be treated with caution. The extent and type of inflammatory involvement in our PE patients, and the influence of inflammation on adropin, was not known. Also, despite excluding patients with a history of malignancy, non-exclusion of patients with other comorbidities and the effect of such comorbidities on adropin levels limit the scope of generalizing our results. The sample size could not be increased for the control group, since it is very difficult to find healthy participants in advanced age.

Conclusion

To conclude, our results suggest that adropin can be used as a preliminary test for excluding the diagnosis of PE. However, since no studies are available that have investigated the efficiency of adropin as a biomarker for PE, we think that the results obtained from our study should not be generalized yet.

Abbreviations

PE: pulmonary embolism, ED: emergency department, ELISA: enzyme-linked immune sorbent assay, CI: Confidence interval, AUC: Area under curve, CTPA: computerized tomography pulmonary angiography, ROC: Receiver Operating Characteristic, TTE: trans-thoracic echocardiography, RV/LV: right ventricle/left ventricle, RVWT: Right ventricle wall thickness, PAWP: Pulmonary arterial wedge pressure

Declarations

Ethics approval and consent to participate:

Ethical approval for this study was obtained from the Non-Invasive Clinical Research Ethics Committee of a local university (registration number - 2019.185.10.06). All methods were performed in accordance with

the relevant guidelines and regulations. Written informed consent was obtained from all patients and healthy volunteers who agreed to participate

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and analyzed for this study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Funding:

The authors declare that they have no fundings.

Authors' contributions:

SO designed the study, performed the data analysis and drafted the manu-script. AC reviewed and edited the manuscript. BIB performed data acquisi-tion. EY performed data acquisition. All authors read and approved the final manuscript

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References

1. Toplis E, Mortimore G. The diagnosis and management of pulmonary embolism. Br J Nurs. 2020;29(1):22–26.
2. Righini M, Robert-Ebadi H, Le Gal G. Diagnosis of pulmonary embolism. Presse Med. 2015;44(12 Pt 2):e385-91.
3. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonaryembolism developed in collaboration with the European Respiratory Society (ERS) European Heart Journal. 2020; 41(4):543–603.
4. Kumar KG, Trevaskis JL, Lam DD, Sutton GM, Koza RA, Chouljenko VN, et al. Identification of adropin as a secreted factor linking dietary macronutrient intake with energy homeostasis and lipid metabolism. Cell Metab 2008;8:468–481.

5. Gao S, McMillan RP, Jacas J, Zhu Q, Li X, Kumar GK, et al. Regulation of substrate oxidation preferences in muscle by the peptide hormone adropin. Diabetes 2014; 63:3242–3252.
6. Wang B, Xue Y, Shang F, Ni S, Liu X, Fan B, et al. Association of serum adropin with the presence of atrial fibrillation and atrial remodeling. J Clin Lab Anal. 2019;33(2): e22672.
7. Aydin S, Eren MN, Yilmaz M, Kalayci M, Yardim M, Alatas OD, et al. Adropin as a potential marker of enzyme-positive acute coronary syndrome. Cardiovasc J Afr. 2017;28(1):40–47.
8. Aydin S, Kuloglu T, Aydin S, Kalayci M, Yilmaz M, Çakmak T, et al. Elevated adropin: a candidate diagnostic marker for myocardial infarction in conjunction with troponin-I. Peptides. 2014;58:91–97.
9. Maciorkowska M, Musiałowska D, Małyszko J. Adropin and irisin in arterial hypertension, diabetes mellitus, and chronic kidney disease. Adv Clin Exp Med. 2019;28(11):1571–1575.
10. Gundogdu G, Gundogdu K. A novel biomarker in patients with knee osteoarthritis: adropin. Clin Rheumatol. 2018; 37(8):2179–2186. https://doi.org/10.1007/s10067-018-4052-z. Epub 2018 Mar 16.
11. Choi HN, Yim JE. Plasma adropin as a Potential Marker Predicting Obesity and Obesity-associated Cancer in Korean Patients with Type 2 Diabetes Mellitus. J Cancer Prev. 2018;23(4):191–196.
12. Bozic J, Borovac JA, Galic T, Kurir T T, Supe-Domic D, Dogas Z. Adropin and Inflammation Biomarker Levels in Male Patients With Obstructive Sleep Apnea: A Link With Glucose Metabolism and Sleep Parameters. J Clin Sleep Med. 2018;14(7):1109–1118.
13. Dronkers CEA, Van der Hulle T, Le Gal G, Kyrle PA, Huisman MV, Cannegieter SC, Klok FA. Subcommittee on Predictive and Diagnostic Variables in Thrombotic Disease. Towards a tailored diagnostic standard for future diagnostic studies in pulmonary embolism: Communication from the SSC of the ISTH. J Thromb Haemost 2017; 15:1040–1043.
14. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS)The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC). European Heart Journal (2020) 41, 543–603 doi:10.1093/eurheartj/ehz405
15. Kucher N, Luder CM, Dornhofer T, Windecker S, Meier B, Hess OM. Novel management strategy for patients with suspected pulmonary embolism. Eur Heart J 2003;24:366_376.
16. Kim HY, Kim KH, Kim J, Park JC. Multimodality cardiovascular imaging in pulmonary embolism. Cardiol J. 2021;28(1):150–160. doi: 10.5603/CJ.a2019.0084. Epub 2019 Sep 3.
17. Perrier A, Roy PM, Sanchez O, Le Gal G, Meyer G, Gourdier AL, et al. Multi detector-row computed tomography in suspected pulmonary embolism. N Engl J Med2005;352:1760–1768.
18. Perrier A, Roy PM, Aujesky D, Chagnon I, Howarth N, Gourdier AL, et al. Diagnosing pulmonary embolism in outpatients with clinical assessment, D-dimer measurement, venous ultrasound, and helical computed tomography: a multi center management study. Am J Med 2004;116:291–299.
19. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, et al. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary

embolism presenting to the emergency department by using a simple clinical model and D-dimer. Ann Intern Med 2001;135:98–107.

20. Righini M, Aujesky D, Roy PM, Cornuz J, de Moerloose P, Bounameaux H, et al. Clinical usefulness of D-dimer depending on clinical probability and cutoff value in outpatients with suspected pulmonary embolism. Arch Intern Med 2004;164:2483–2487.
21. Lovren F, Pan Y, Quan A, Singh KK, Shukla PC, Gupta M, et al. Adropin is a novel regulator of endothelial function. Circulation 2010; 122: 185–192
22. Sato K, Yamashita T, Shirai R, Shibata K, Okano T, Yamaguchi M, et al. Adropin Contributes to Anti-Atherosclerosis by Suppressing Monocyte-Endothelial Cell Adhesion and Smooth Muscle Cell Proliferation. Int J Mol Sci 2018, 19(5), 1293; https://doi.org/10.3390/ijms19051293
23. Kaluzna M, Pawlaczyk K, Schwermer K, Hoppe K, Czlapka-Matyasik M, Yusuf Ibrahim A, et al. Adropin and irisin: new biomarkers of cardiac status in patients with end-stage renal disease? A preliminary study. Adv Clin Exp Med. 2019;28(3):347–353.

Figures

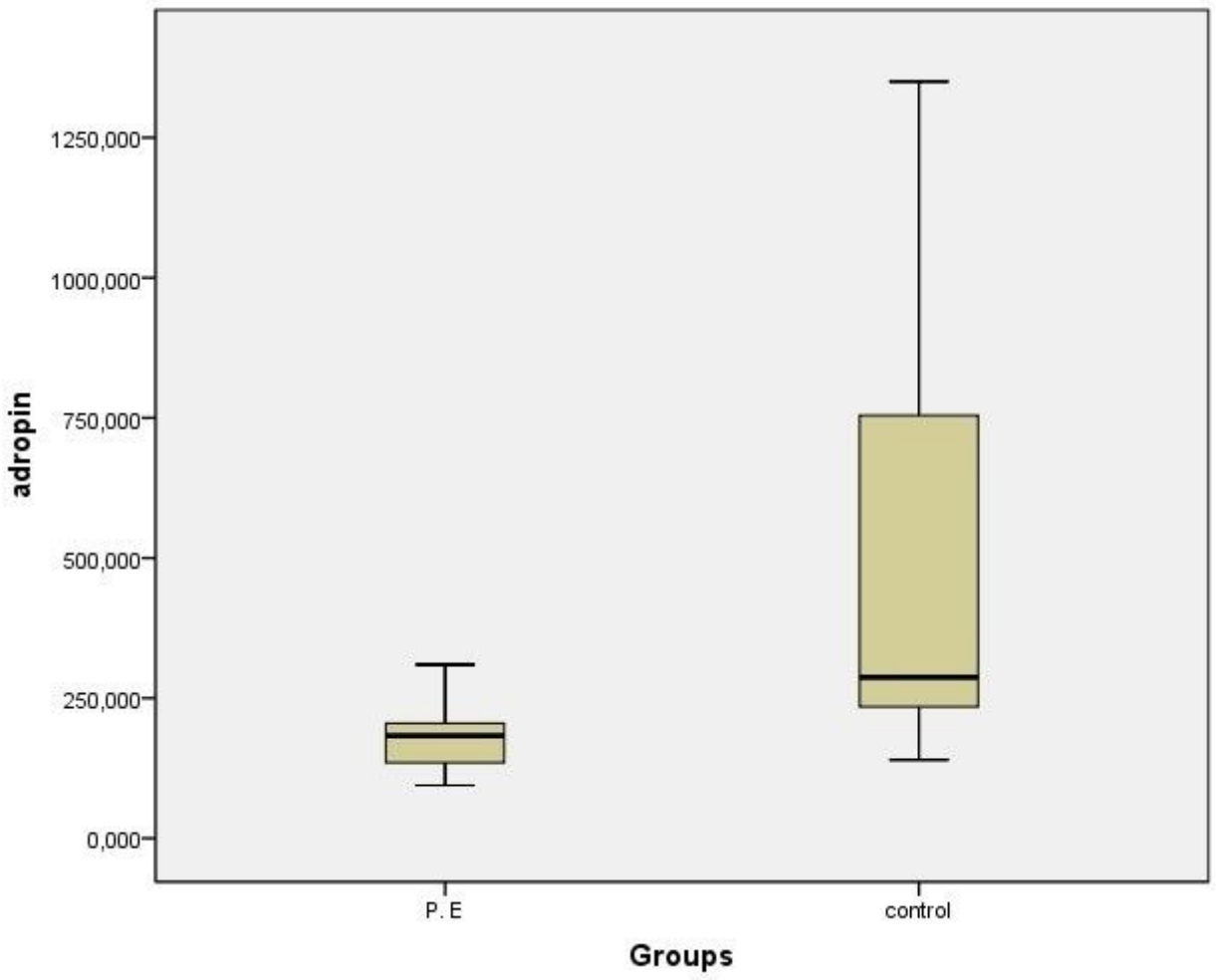

Figure 1

Normal distribution of pulmonary embolism and control group adropin values

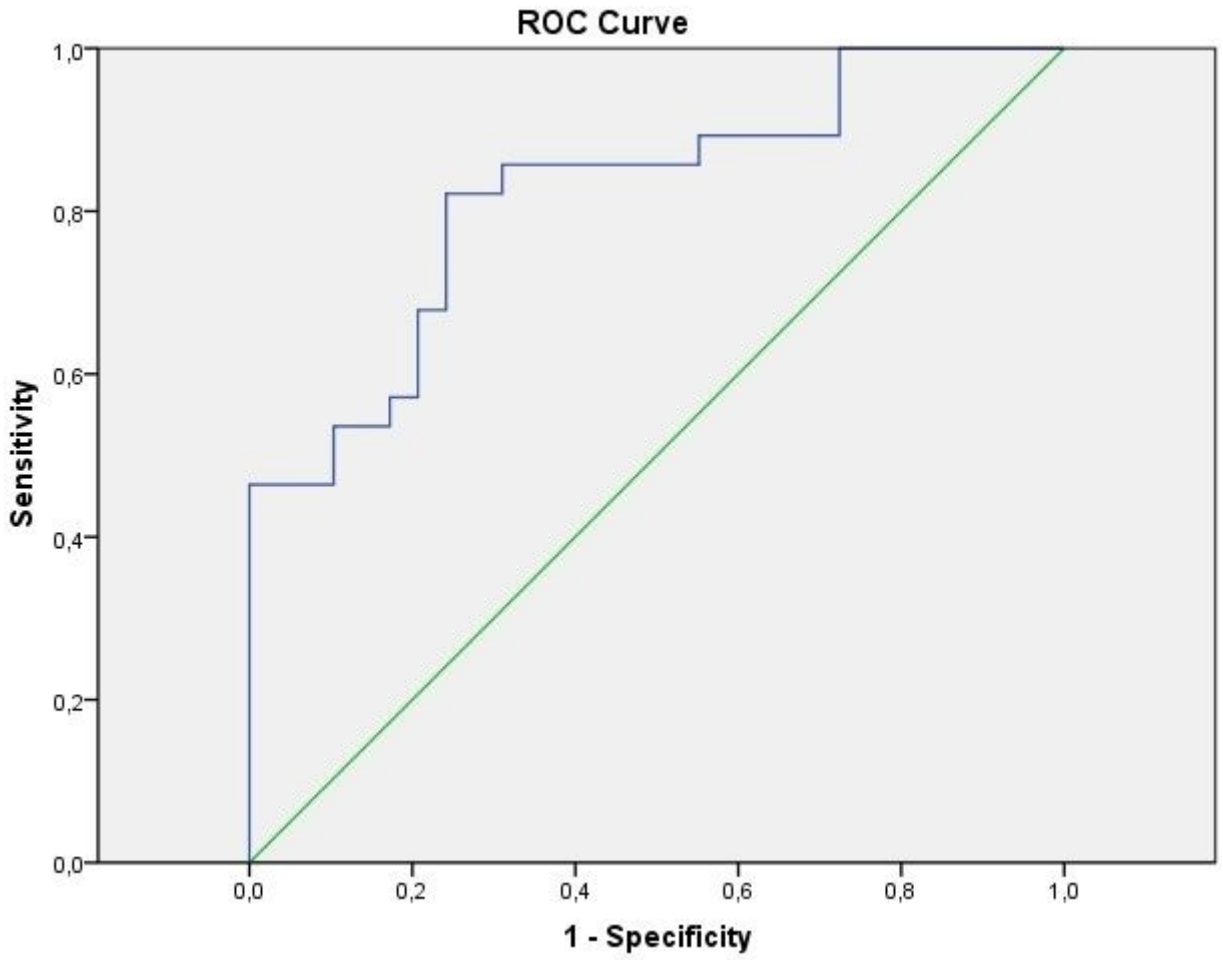

Figure 2

ROC curve of adropin value at excluding pulmonary embolism (blue curve). 95% CI, AUC: 0.821 (0,71-0,93)