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Gaisböck Syndrome in Obstructive Sleep Apnea and its Impact on Cardiovascular System: Two Clinical Cases

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Abstract. ***Background:*** Elevated blood pressure and hypertension are major challenges for health care systems as risk factors for both cardiovascular diseases and damage of target organs. Some causes of hypertension such as polycythemia, kidney damage, and endocrine pathology may remain undiagnosed and, consequently, untreated. The impact of polycythemia on the cardiovascular system is already well established. However, the association of hypertension and polycythemia without splenomegaly (Gaisböck syndrome) in patients with obstructive sleep apnea (OSA) is less understood. Gaisböck syndrome requires special attention and more careful study as a condition associated with a worse prognosis.

The aim of the publication is to highlight polycythemia as an underrecognized factor that may negatively affect the cardiovascular system in patients with OSA, particularly in mild forms that often remain uncontrolled in routine clinical practice, as well as to underline the role of microcirculation disturbances and their timely diagnostics in this clinical situation.

Case reports: Both presented patients had OSA without proper Continuous Positive Airway Pressure (CPAP) therapy and met the criteria of Gaisböck syndrome (mild hypertension, polycythemia without splenomegaly). The first case describes a 48-year-old patient at an early stage of cardiovascular continuum (obesity, recently diagnosed type 2 diabetes). The second case describes a 56-year-old patient with coronary artery disease (history of myocardial infarction and revascularization procedure, mildly reduced left ventricular ejection fraction), obesity, and prediabetes. In both cases, biomicroscopy of the bulbar conjunctiva revealed marked microcirculatory abnormalities. Understanding the patients' clinical status allowed the consultant to adjust the therapy and tactics for further diagnostics.

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Conclusions: The presented cases emphasize the importance of identifying less obvious causes and risk factors of hypertension in order to eliminate them in a timely manner and improve the prognosis of the patient. Further research is needed to clarify the role of changes in the microcirculatory bed in patients with Gaisböck syndrome associated with OSA and their contribution in the development of internal pathology, particularly cardiovascular disease.

Keywords: hypertension, elevated blood pressure, secondary hypertension, obstructive sleep apnea, Gaisböck syndrome, polycythemia, microcirculation.

Gaisböcko sindromas obstrukcinės miego apnėjos atveju ir jo poveikis širdies ir kraujagyslių sistemai: du klinikiniai atvejai

Santrauka. ***Įvadas:*** Padidėjęs kraujospūdis ir hipertenzija yra didelė problema sveikatos priežiūros sistemai, nes tai yra tiek širdies ir kraujagyslių ligų, tiek tikslinių organų pažeidimų rizikos veiksniai. Kai kurios hipertenzijos priežastys, pavyzdžiui, policitemija, inkstų pažeidimai ir endokrininės patologijos, gali likti nediagnozuotos ir todėl negydytos. Policitemijos poveikis širdies ir kraujagyslių sistemai yra gerai žinomas. Tačiau hipertenzijos ir policitemijos be splenomegalijos (Gaisböcko sindromo) sąsaja pacientams, sergantiems obstrukcine miego apnėja (OMA), yra mažiau ištirta. Gaisböcko sindromui reikia skirti ypatingą dėmesį ir jį atidžiau tirti, nes tai yra būklė, susijusi su blogesne prognoze.

Šio straipsnio tikslas – atkreipti dėmesį į policitemiją kaip nepakankamai pripažintą veiksnį, kuris gali neigiamai paveikti širdies ir kraujagyslių sistemą pacientų, sergančių OMA, ypač lengvomis formomis, kurios įprastoje klinikinėje praktikoje dažnai lieka nekontroliuojamos, taip pat pabrėžti mikrocirkuliacijos sutrikimų vaidmenį ir jų diagnostiką šioje klinikinėje situacijoje laiku.

Atvejų aprašymai: Abu juose aprašyti pacientai sirgo OMA ir negavo tinkamo nuolatinio teigiamo kvėpavimo takų slėgio gydymo, be to, atitiko Gaisböcko sindromo kriterijus (lengva hipertenzija, policitemija be splenomegalijos). Pirmame atvejo aprašyme pateikiama 48 metų paciento, kuriam buvo ankstyvoji širdies ir kraujagyslių ligų raidos stadija (nutukimas, neseniai diagnozuotas 2 tipo cukrinis diabetas), ligos istorija. Antrame atvejo aprašyme pateikiama informacija apie 56 metų pacientą, sergantį koronarine širdies liga (miokardo infarkto ir revaskuliarizacijos procedūros anamnezė, šiek tiek sumažėjusi kairiojo skilvelio išstūmimo frakcija), nutukimu ir prediabetu. Abiem atvejais bulbarinės junginės biomikroskopija atskleidė ryškius mikrocirkuliacijos sutrikimus. Pacientų klinikinės būklės supratimas leido konsultantui pakoreguoti gydymą ir tolesnės diagnostikos taktiką.

Išvados: Remiantis pateiktais atvejais pabrėžiama, kaip svarbu nustatyti mažiau akivaizdžias hipertenzijos priežastis ir rizikos veiksnius, siekiant laiku juos pašalinti ir pagerinti paciento prognozę. Reikia atlikti tolesnius tyrimus, siekiant išsiaiškinti mikrocirkuliacijos pokyčių vaidmenį pacientams, sergantiems Gaisböcko sindromu, susijusiu su OMA, ir jų įtaką vidaus organų patologijų, ypač širdies ir kraujagyslių ligų, vystymuisi.

Raktažodžiai: hipertenzija, padidėjęs kraujospūdis, antrinė hipertenzija, obstrukcinė miego apnėja, Gaisböcko sindromas, policitemija, mikrocirkuliacija.

Introduction

Hypertension remains one of the most common cardiovascular pathologies worldwide. More than 1.2 billion people – i.e., nearly one-third of the adult population – have *Blood Pressure* (BP) levels attributable to hypertension [1,2]. The number of individuals who need special attention for cardiovascular prevention has increased further following the publication of updated guidelines on the management of patients with an elevated BP, as the paradigm of BP perception has changed, and levels of 120–139/70–89 mm Hg are now considered an elevated BP [3]. It is of importance to note that, according to the latest report of the World Health Organization, only 54% of adults with hypertension are diagnosed, 42% receive treatment, and merely 21% have their hypertension controlled [1,2]. Often, the cause of insufficient control of hypertension, and particularly of its resistant form, is secondary hypertension [3]. Identification of secondary forms of hypertension is

critically important because many of them are potentially reversible, whereas, timely recognition and treatment on the underlying cause may lead to normalization of BP levels. The main forms of secondary hypertension are described in detail in various regulatory documents and reviews [3–5]. Most commonly, when considering secondary hypertension, attention is focused on endocrine and renoparenchymal/renovascular types of hypertension, although the list of causes of secondary hypertension is considerably broader.

Recently, *Obstructive Sleep Apnea* (OSA) has been actively studied as a cause of secondary hypertension [3–7]. OSA affects approximately 10–15% of women and 15–30% of men worldwide [8]. Although hypoxemia is on the list of OSA pathogenetic effects on BP levels, it is considered as a cause of systemic inflammation and oxidative stress rather than a factor that affect hematopoiesis, which, in turn, can enhance the negative effect of OSA on BP levels [7,8].

Unfortunately, in the clinical practice, the mild increase in routine blood test parameters is often overlooked. An increase in the red blood cell count, hemoglobin and hematocrit levels may indicate polycythemia; these changes in blood parameters, associated with hypertension without splenomegaly, are known as Gaisböck syndrome [9]. We have previously addressed Gaisböck syndrome in smokers [10]. Therefore, the aim of this case presentation is to highlight polycythemia as an underrecognized factor that may negatively affect the cardiovascular system in patients with OSA, particularly in mild forms that often remain uncontrolled in the routine clinical practice, as well as to underline the role of microcirculation disturbances and their timely diagnostics in this clinical situation.

Clinical case 1

A 48-year-old Caucasian male patient with bilateral lower limb amputations due to combat trauma was examined. The main characteristics as well as laboratory and instrumental findings are summarized in Table 1. The patient applied for a follow-up examination and assessment of the treatment effectiveness in February 2025.

The patient had experienced elevated BP levels for the past 5 years; recently, type 2 diabetes was diagnosed. He had repeatedly undergone inpatient examinations and treatment of hypertension. However, he had not taken prescribed antihypertensive medications regularly.

On detailed interview during the index examination, the patient reported elevated BP levels above 140/90 mm Hg accompanied with headache, tinnitus, general fatigue, poor sleep, and shortness of breath that worsened with minor physical exertion, a feeling of lack of air, and general weakness. Notably, he described pronounced daytime drowsiness, episodes of sleep-disordered breathing including a sensation of breathing cessation during sleep. Additional complaints included heaviness in the right hypochondrium, heartburn, and difficulty in nasal breathing.

Table 1. Results of laboratory and instrumental examinations of the patients

Data	Patient 1		Patient 2	
	Results	Interpretation	Results	Interpretation
Main characteristics of the patients				
Body mass index, kg/m^2	37.7	Obesity 2 stage (adjusted body mass index considering limb amputation [11, 12])	36.4	Obesity 2 stage
Smoking	Up to 15-20 cigarettes per day	Cardiovascular risk factor	No	
Endocrine causes of hypertension	Excluded	-	Excluded	-
Renal causes of hypertension	Excluded	-	Excluded	-

Data	Patient 1		Patient 2	
	Results	Interpretation	Results	Interpretation
Systolic BP, mm Hg	150	Mild hypertension	130-145	Mild hypertension
Diastolic BP, mm Hg	90	Mild hypertension	85-95	Mild hypertension
Heart rate, per 1 minute	90	Tendency to tachycardia	56	Sinus bradycardia
Psychiatrist's examination	Anxious asthenic state with an insomniac component and manifestations of emotional and volitional instability, somatogenically determined		No need, no complaints	
Chest X-ray	Pathological changes are absent			
Liver function	Pathological changes are absent			
SCORE2-Diabetes risk, %	16.8	High 10-year risk of cardiovascular event	-	-
Cardiovascular risk	-	High by SCORE2-Diabetes	History of myocardial infarction & revascularization	Very high
Written consent of the patient for biomicroscopy of the bulbar conjunctiva and inclusion of his data in case publication while maintaining confidentiality	Yes		Yes	
Complete blood count and biochemistry				
White blood cells, $\cdot 10^9$/L	8.3; 8.7	Normal	7.0; 9.5	Normal; slightly elevated
Platelets, $\cdot 10^9$/L	228; 281	Normal	163; 196	Near the lower limit of normal
Red blood cells, $\cdot 10^{12}$/L	5.62; 5.83	Elevated	5.68; 5.85	Elevated
Hemoglobin, g/L	176; 181	Elevated	166; 178	Elevated
Hematocrit, %	54.8; 53.3	Elevated	49.2; 51.5	Elevated
Fasting glucose, mmol/L	7.5	Elevated (type 2 diabetes)	5.5	Normal
Glycated hemoglobin, %	6.8	Elevated (type 2 diabetes) but controlled	6.24	Prediabetes
HOMA-index	-	-	6.97; 3.95	Elevated
Total cholesterol, mmol/L	6.18	Elevated	3.41	Normal
Low-density lipoproteins, mmol/L	3.8	Elevated	1.85	Target level is not achieved (less than 1.4 mmol/L)
High-density lipoproteins, mmol/L	1.1	Normal	1.18	Normal
Very low-density lipoproteins, mmol/L	1.28	Elevated	0.38	Normal
Triglycerides, mmol/L	2.82	Elevated	0.69	Normal
Creatinine, μmol/L	93.,3	Normal	77	Normal
eGFR (CKD-EPI equation), mL/min/1.73m^2	71	Chronic kidney disease stage 2 (with correction for the lost body part [11, 12]	101	Normal
General urine analysis		Normal		Normal

Data	Patient 1		Patient 2	
	Results	Interpretation	Results	Interpretation
Electrocardiographic (ECG) examination				
Heart rate, per 1 minute	104	Sinus tachycardia	48	Sinus bradycardia
PQ interval, ms	151.3	Normal	200	Normal (as for bradycardia)
QRS interval, ms	94.6	Normal	110	Normal (as for bradycardia)
QT interval, ms	358	Normal	460	Prolonged
QTc (Fridericia equation), ms	430	Slightly prolonged	427	Slightly prolonged
Signs of LV hypertrophy	No		No	
Other ECG changes	Flattening of the T wave was observed in all leads, negative T wave – in leads V5, V6		Signs of a previous Q-myocardial infarction of the LV posterior wall	
Echocardiography				
Aorta diameter, cm	Up to 3.1	Normal	3.3	Normal
Left atrium diameter, cm	3.3	Normal	5.0	Dilated
LV end-diastolic volume, mL	112	Normal	161	Mildly increased
LV end-systolic volume, mL	61	Normal	91	Increased
LV EF, %	62	Normal	44	Mildly reduced
Thickness of interventricular septum, cm	1.4	Thickened	1.2-1.38	Thickened
Thickness of posterior wall of LV, cm	1.1	Normal	1.05	Normal
LV mass index, g/m^2	130	Criteria of LV hypertrophy (body surface area adjusted for lost part of the body [12])	125	Criteria of LV hypertrophy
Right ventricle end-diastolic diameter, cm	2.2	Normal	2.6	Normal
LV diastolic dysfunction	Relaxation disturbances		Pseudonormalization	
Gaisböck syndrome criteria				
Polycythemia major criteria: elevated hemoglobin (>165 g/L)	Yes, with repeated changes			
Polycythemia major criteria: elevated hematocrit (>0.49)	Yes, with repeated changes			
Hypertension	Yes, mild			
Absence of splenomegaly, also confirmed by ultrasound examination	Yes			
Other signs typical for Gaisböck syndrome				
Male gender	Yes			
Overweight or obesity	Yes			
Dyslipidemia	Yes			
Diabetes or carbohydrate metabolism disorders	Yes			
Diuretic treatment or other causes of hypovolemia and, thus, secondary polycythemia?	No			

Note. Abbreviations in use: BP – blood pressure; eGFR – estimated glomerular filtration rate; CKD-EPI – Chronic Kidney Disease Epidemiology Collaboration Formula; EF – ejection fraction; HOMA – Homeostatic Model Assessment; LV – left ventricular.

Ambulatory cardiorespiratory monitoring (Somno chek micro-CARDIO) confirmed severe OSA syndrome. The patient demonstrated a high risk of both cardiovascular disease and sleep-disordered breathing as well as a significant risk of fragmented sleep due to frequent awakenings. Automatic analysis also detected signs of atrial fibrillation associated with OSA. *Continuous Positive Airway Pressure* (CPAP) therapy was therefore recommended.

The presence of polycythemia criteria combined with mild hypertension and without splenomegaly led us to suspect Gaisböck syndrome associated with severe OSA. The hematologist suggested a secondary nature of the polycythemia and recommended a reassessment of the patient's condition and blood test parameters two months after the start of the CPAP therapy.

It was recommended that the patient should receive antihypertensive therapy, anticoagulant therapy (CHA2DS2-VA – 2 points), statin therapy, hypoglycemic therapy, and CPAP therapy for OSA.

Polycythemia can affect the total systemic vascular resistance by changing the rheological properties of the blood, which, in turn, will contribute to the maintenance of hypertension and the development of cardiovascular diseases. In this case, the patient had signs of LV hypertrophy, early-stage chronic kidney disease, and episodes of previously undiagnosed atrial fibrillation during polysomnography despite the mild hypertension. Moreover, the patient faced a high cardiovascular risk according to SCORE2-Diabetes.

We decided to assess the patient's microcirculatory bed by using the method of biomicroscopy of the bulbar conjunctiva with assessment of vascular, extra-, and intravascular changes according to a previously described methodology [13,14] (Fig. 1). It is well established that bulbar conjunctiva microcirculation reflects the state of the total microcirculation [13,14]. The examination was conducted by using a slit lamp with subsequent photographic documentation using the macro mode of a smartphone.

The obtained images revealed pronounced microcirculatory impairment (see Fig. 1). Areas of perivascular edema were detected, the arteriolovenular ratio was at the level of 1/4–1/5 (the normal ratio is in the range of 1/1–1/2), indicating spastic-atonic vasculopathy typical for hypertension. A developed network of anastomoses was also noted. Several intravascular abnormalities were detected, including sludge, stasis, and an increased aggregation of red blood cells. These changes are additional factors in the development of circulatory disorders at the level of the microcirculatory bed and may increase tissue hypoxia. Newly formed vessels are likely to reflect a response to tissue hypoxia.

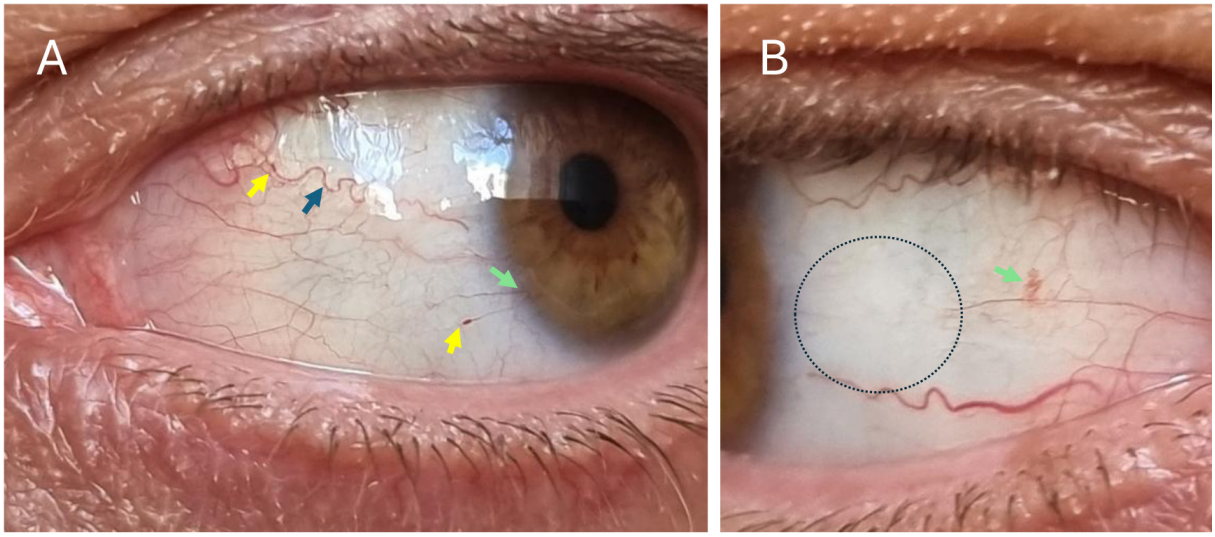


Fig. 1. Microcirculatory bed of the bulbar conjunctiva of the patient (Clinical Case 1). The yellow arrows (Photo A) point to the areas of pronounced aggregation and stasis of red blood cells, the blue arrow (Photo A) points to the area of blood sludging, the green arrows in photos A and B point to newly formed vessels, the dotted line (Photo B) shows an area of perivascular edema

It should be noted that, despite the objective criteria for polycythemia, no specific examination to clarify the etiology of polycythemia was undertaken prior to the index visit. Moreover, polycythemia was not included in the patient's diagnosis. In our opinion, timely correction of hypoxia and targeted management of the risk factors for internal pathology – particularly cardiovascular diseases – may significantly affect the path of this patient along the cardiovascular continuum, which has undoubtedly begun.

A notable feature of this case is that the patient with a relatively short history of mild hypertension and type 2 diabetes already has target organ damage, particularly the cardiovascular system including inadequate sinus tachycardia, episodes of atrial fibrillation, LV hypertrophy, LV diastolic dysfunction, and microcirculation disorders. At the same time, polycythemia in the context of Gaisböck syndrome as one of the factors that can contribute to and aggravate these changes was not actively considered and controlled due to the mildly elevated hemoglobin and hematocrit levels.

Clinical Case 2

A 56-year-old Caucasian male patient was evaluated. The main characteristics as well as results of the patient's laboratory and instrumental examinations are presented in Table 1.

Six years ago, the patient experienced a Q-wave myocardial infarction of the LV posterior wall, and subsequently underwent coronary intervention with stent implantation in the circumflex branch of the left coronary artery. The patient received dapagliflozin, nebivolol, atorvastatin, and rivaroxaban. Echocardiographic assessment demonstrated a deterioration of intracardiac hemodynamics (see Table 1); however, clinical signs of congestive heart failure were absent.

Moreover, the patient was diagnosed with insomnia and OSA syndrome in 2019. Since then, the patient has been receiving CPAP therapy.

During the index consultation, the patient's BP level was measured at a level of 145/95 mm Hg. The patient's complaints included general fatigue, and poor sleep. At this time, the patient received CPAP therapy on an irregular basis.

Over the years of observation, progressive weight gain has been observed, accompanied with signs of insulin resistance. Despite statin therapy, low-density lipoprotein cholesterol levels remained above the recommended target value. The patient had mild hypertension. Since November 2024, the patient's hemoglobin and hematocrit levels have reached the criteria attributable to polycythemia (see Table 1). However, these findings were initially not considered clinically significant due to the relatively mild elevation of the parameters. During the recent examination, further negative dynamics in both hemoglobin and hematocrit levels were observed, which required special attention in the context of concomitant pathology including myocardial ischemia, hypertension, insulin resistance, and obesity. The combination of polycythemia and mild hypertension allowed us to consider this case as Gaisböck syndrome. Polycythemia was regarded as, most likely, secondary in nature, associated, like in the previous case, with hypoxia on the background of OSA. Given the presence of polycythemia, the patient also underwent biomicroscopy of the bulbar conjunctiva, which revealed several pathological changes in the microcirculatory bed (Fig. 2).

Overall, the microcirculatory impairment of the bulbar conjunctiva in this patient was even more significant than the one observed in the patient described in the first case. Large areas of perivascular edema and lipid deposits had a negative influence on the blood flow. The arteriolovenular ratio at 1/5–1/6 indicated severe spastic-atonic vasculopathy. Additional findings included areas of pronounced vascular tortuosity, a developed anastomotic network, a zone of probable hemosiderin deposition as a sign of recent hemorrhage in this area, stasis and an increased erythrocyte aggregation. Notably, excessive lipid accumulation was observed, with features consistent with pinguecula formation and a prolapse of orbital fat.

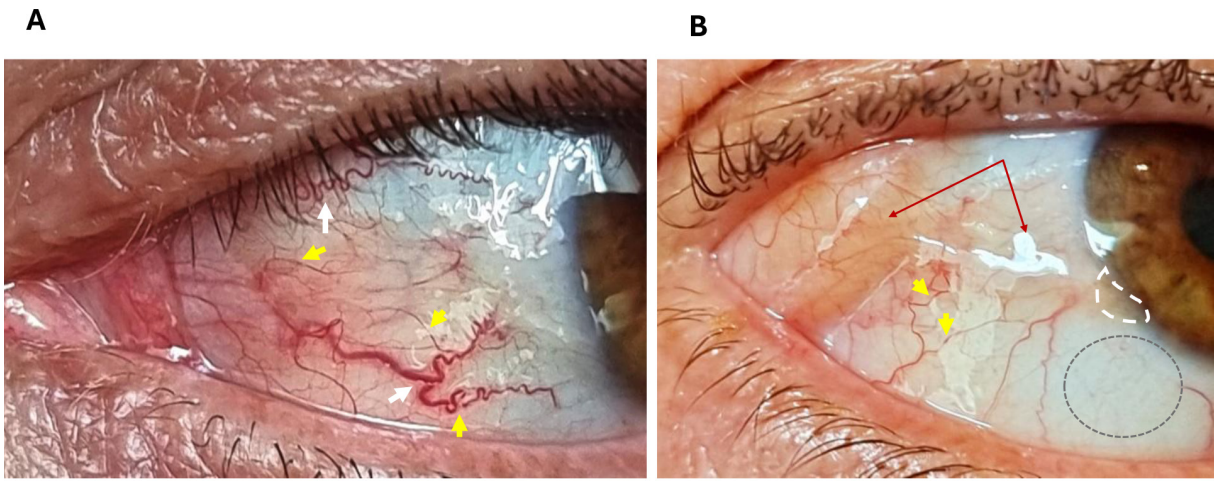


Fig. 2. Microcirculatory bed of the bulbar conjunctiva of the second patient with pronounced pathological changes (photos taken with a smartphone in the 'macro' mode). The yellow arrows (Photos A and B) point to the areas of pronounced aggregation and stasis of red blood cells, the white arrows (Photo A) point to pronounced vascular tortuosity with a meandering, corkscrew-like configuration of microvessels. In Photo B, the red arrows point to the areas of lipid deposition within the conjunctiva, the dark line shows an area of edema and reduced vascularization, while the light dotted line shows an area of probable hemosiderin deposition that is considered as a sign of recent hemorrhage.

Based on the results of the follow-up examination, the patient's therapy was modified. Rivaroxaban was discontinued due to the lack of indication and replaced with acetylsalicylic acid. Diuretic therapy, mineralocorticoid receptor antagonist and angiotensin-converting enzyme inhibitor were added. A more potent statin (rosuvastatin) was prescribed with subsequent consideration of a combination therapy with ezetimibe.

The hematologist recommended a follow-up and correction of the CPAP therapy, as well as a repeat blood test after 2 months of regular CPAP therapy with subsequent selection of diagnostic tactics.

A peculiarity of this case, similar to the previous one, is that the elevated hemoglobin level and an increased red blood cell count, along with the abnormal hematocrit level, were not given much attention, being considered initially as a symptom of chronic hypoxia caused by OSA. Furthermore, this patient's platelet count was low. Although the lipid-lowering therapy improved the lipid profile, it was accompanied with significant extravascular lipid deposition. These findings underscore the need for an individualized therapeutic approach with careful consideration of the platelet function and lipid metabolism.

Discussion

The purpose of our report is to emphasize that OSA can be associated not only with acute respiratory disorders, in particular, with acute hypoxia during apneic episodes, but also with long-term effects that affect the hematopoietic system, and, as a result, it may exert a negative influence on the cardiovascular system. In addition, the possibility of polycythemia vera or other etiologies of erythrocytosis cannot be excluded in patients with OSA and elevated hemoglobin and/or hematocrit levels. Therefore, diagnostic evaluation should be continued until the cause of polycythemia has been determined. We retrospectively selected two cases of patients with OSA who had signs of polycythemia from the general hospital registry. In both cases, polycythemia was interpreted within the framework of the main diagnosis, and thus, no further differential diagnostic search and exclu-

sion of polycythemia vera were carried out before index visits. These cases were chosen to illustrate the importance of a careful evaluation of polycythemia as a potential adverse confounder that influences the cardiovascular system in patients with OSA and the need to recognize Gaisböck syndrome in such patients.

The authors of extensive literature reviews devoted to the influence of OSA on BP do not mention polycythemia as an additional risk factor for the development of hypertension in such patients. However, as early as in 1905, a case of mild hypertension in a person with signs of polycythemia was already described [9]. This clinical phenomenon was later called Gaisböck syndrome, which is now commonly defined as a combination of polycythemia and mild hypertension without splenomegaly [10,15,16]. A subsequent analysis identified Gaisböck syndrome as a factor associated with a higher cardiovascular risk [16]. Krishnamoorthy et al. [16] found significantly increased prevalence of all cardiovascular risk factors/events in patients with polycythemia; heart failure, coronary artery disease, acute coronary syndrome, in-hospital death, and cardiac arrest were significantly more often observed in the group of patients with polycythemia compared with those without such a condition [16]. After adjusting for several factors, polycythemia remained a determinant of hypertension (odds ratio 1.37 [1.28–1.45]; $p<0.001$) [16]. It should be noted that hypertension and polycythemia are not the only signs of Gaisböck syndrome. It is associated with the male sex, smoking, an excessive body weight or obesity, dyslipidemia, hyperuricemia, impaired carbohydrate metabolism, and increased renin levels [15,16].

There is some controversy regarding the frequency of polycythemia in patients with OSA, which may also depend on the diagnostic criteria applied. Currently, we are guided to define polycythemia as an increase in hemoglobin >165 g/L in men and >160 g/L in women and/or hematocrit >49% in men and >48% in women [17,18]. In a study published in 2016, Gangaraju et al., based on a survey of more than 500 patients with OSA, reported a low frequency of polycythemia in such patients – at approximately 4.5% according to hemoglobin indicators and 3.2% based on a diagnostically significant change in hematocrit [19]. However, these authors defined polycythemia as a hemoglobin level >159 g/L in women and >178 g/L in men, which is significantly higher than the current limits for men. In a later study involving almost 900 patients, Zeng et al. noted that the frequency of polycythemia was associated with overlap syndrome and more severe OSA, whereas the percentage of the total sleep time with oxygen saturation <90% was an independent factor in polycythemia development [20]. Martelli et al. studied the prevalence of elevated hemoglobin and hematocrit levels in 3,654 patients with OSA and found an overall polycythemia prevalence of 2% in mild-to-moderate and 6% in severe OSA [18]. In our routine practice, we observe cases consistent with Gaisböck syndrome in young male patients with OSA quite often, which requires certain diagnostic measures to exclude polycythemia vera and control blood parameters if signs of polycythemia are detected.

OSA, which is more often observed in obese patients, is an additional cardiovascular risk factor, particularly contributing to the hypertension development and the worsening of ischemia due to the effect on the microcirculation [7,21]. Schematically, we present the confounders to BP elevation caused by OSA in Fig. 3.

We observed pathological changes at the microcirculatory level in both cases presented, but more unfavorable changes in the microcirculatory bed were found in the second patient. This may occur not only due to the deterioration of the rheological properties of the blood due to polycythemia, but may also be associated with other factors, such as a reduced platelet count, and the presence of atherosclerotic artery disease.

The role of platelets in maintaining microcirculatory homeostasis and regulating the microvascular tone has been recognized and extensively studied [22,23]. Xiang et al. [23] described in detail the effect of platelets on microcirculation in patients with COVID-19. According to these authors, a low

platelet count correlated with the severity of COVID-19 because activated platelets lose their ability to maintain the normal state of the vascular wall, which leads to an increase in its permeability. The authors emphasized two platelet-related mechanisms contributing to microcirculation disorders during the acute inflammatory process: (i) an insufficient platelet count and (ii) hyperactivation of platelets, which switch to thrombus formation and become less involved in regulating the vascular wall function [23]. Thus, antiplatelet therapy in COVID-19 may not only reduce the risk of thrombotic complications but may also preserve the platelet availability to maintain the microcirculation regulation and other functions not related to the thrombus formation.

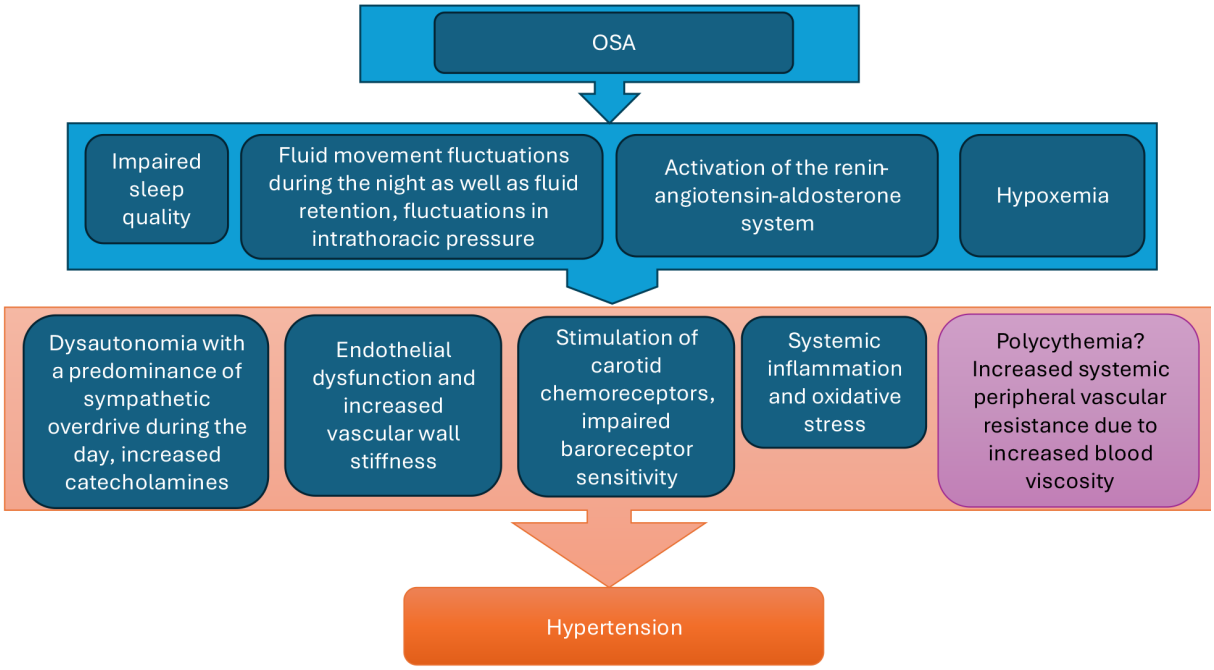


Fig. 3. Pathogenetic influence of OSA on BP levels

Platelets are a depot of serotonin which is an important mediator of microcirculation. Some studies suggest that serotonin may be considered as a marker of coronary microvascular dysfunction in patients with myocardial ischemia in the absence of obstructive lesions of the coronary arteries [24]. In the patient described in Clinical Case 2, the platelet count remained near the lower limit of normal ($163–196 \cdot 10^9$/L) throughout the entire observation period, which could also worsen the microcirculation state, and which led to the decision to initiate acetylsalicylic acid in order to achieve the above-mentioned positive effects on microcirculation.

Another notable feature of the second case was the extraordinary lipid deposition in tissues, detected during bulbar conjunctiva biomicroscopy despite a well-controlled lipid profile under statin therapy. The patient had low levels of total cholesterol and low-density lipoprotein cholesterol, as well as triglycerides. This clinical scenario opens up another important discussion: How should a patient with generally adequate lipid lowering by statin therapy, but with signs of extensive tissue lipid accumulation be managed? The accumulation of lipids in locations other than adipose tissue indicates an imbalance between the supply of fatty acids to cells and their oxidation, and the inability to dispose of excess triglycerides in subcutaneous adipose tissue [25,26]. Such findings indicate a severe violation of lipid metabolism, which should be considered when managing the patient.

Finally, it is impossible to determine the contribution of each of the cardiovascular risk factors identified in these patients, including Gaisböck syndrome, to the development of microcirculation

disturbances. However, it should be noted that the presence of polycythemia may be considered as an additional cardiovascular risk factor, and an independent risk factor for hypertension [16]. It is important that secondary polycythemia can be eliminated by addressing its underlying cause, which, in these cases, is OSA. We previously described the positive impact of addressing the underlying cause of secondary polycythemia in a patient with Gaisböck syndrome on the heart rate, BP levels, and blood test results [10]. In this report, we did not intend to present polycythemia as a leading factor influencing microcirculation in a patient with hypertension, but we did want to highlight its presence and the need to consider it when managing such patients.

The limitation of our study is that it presents only individual clinical cases, which may be relatively unique and not representative of most patients with hypertension and OSA. However, this case-based approach was intentional as our primary goal was to highlight the need for further study of hematopoiesis, rheological properties of blood, and the state of microcirculation in such patients. In the presented cases, the level of erythropoietin, the red blood cell mass index, or the presence of the JAK2 V617F or JAK2 exon 12 mutations were not assessed due to a mild elevation of hemoglobin and hematocrit levels along with the presence of an alternative plausible explanation for the cause of polycythemia, namely, OSA. We did not aim to estimate the frequency of Gaisböck syndrome among patients with OSA at our institution as this condition may be more common among military personnel due to some associated risk factors such as the male predominance, smoking, hypovolemia, stress, combat trauma, etc. Therefore, such findings cannot be directly extrapolated to the general population.

Conclusions

OSA syndrome can influence BP levels not only due to the previously described mechanisms (impact on sleep, fluid movement and retention, and activation of the renin-angiotensin system), but also due to hypoxia (as a cause of polycythemia) and the changes in microcirculation. This influence, along with other confounders, may worsen the course of cardiovascular diseases.

The presented cases demonstrate the need to consider the causes and risk factors of an elevated BP that are not obvious at a first glance, in order to eliminate them in a timely manner and improve the prognosis of a patient with hypertension.

In our opinion, bulbar conjunctiva biomicroscopy is a convenient and illustrative method for assessing microcirculation in patients with polycythemia and hypertension.

It is necessary to conduct further research with the objective to clarify the role of changes in the microcirculatory bed in patients with OSA-associated Gaisböck syndrome and their contribution to the development of pathology of internal organs, and particularly cardiovascular disease.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

N. S.: Conceptualization, Methodology, Formal Analysis, Investigation, Writing – Original Draft Preparation, Writing – Review & Editing.

V. T.: Methodology, Investigation, Writing – Review & Editing, Visualization.

S. B.: Conceptualization, Methodology, Formal Analysis, Investigation, Writing – Original Draft Preparation, Writing – Review & Editing.

References

1. World Health Organization. *Global report on hypertension: the race against a silent killer*. World Health Organization; 2023. Accessed July 19, 2025. https://www.who.int/publications/i/item/9789240081062
2. Kario K, Okura A, Hoshide S, et al. The WHO Global report 2023 on hypertension warning the emerging hypertension burden in globe and its treatment strategy. *Hypertens Res*. 2024;47(5):1099-1102. doi:10.1038/s41440-024-01622-w
3. McEvoy JW, McCarthy CP, Bruno RM, et al. 2024 ESC Guidelines for the management of elevated blood pressure and hypertension: Developed by the task force on the management of elevated blood pressure and hypertension of the European Society of Cardiology (ESC) and endorsed by the European Society of Endocrinology (ESE) and the European Stroke Organisation (ESO). *Eur Heart J*. 2024;45(38):3912-4018. doi:10.1093/eurheartj/ehae178
4. Sudano I, Suter P, Beuschlein F. Secondary hypertension as a cause of treatment resistance. *Blood Press*. 2023;32(1):2224898. doi:10.1080/08037051.2023.2224898
5. Chen ZW, Chan CK, Lin CH, et al. Evaluations of secondary hypertension and laboratory data in the elderly population. *J Formos Med Assoc*. 2025;124 Suppl 1:S24-S31. doi:10.1016/j.jfma.2024.07.020
6. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J*. 2018;39(33):3021-3104. doi:10.1093/eurheartj/ehy339
7. Bangash A, Wajid F, Poolacherla R, Mim FK, Rutkofsky IH. Obstructive Sleep Apnea and Hypertension: A Review of the Relationship and Pathogenic Association. *Cureus*. 2020;12(5):e8241. doi:10.7759/cureus.8241
8. Kwon Y, Tzeng WS, Seo J, et al. Obstructive sleep apnea and hypertension; critical overview. *Clin Hypertens*. 2024;30(1):19. doi:10.1186/s40885-024-00276-7
9. Gaisböck F. Die Bedeutung der Blutdruckmessung für die ärztliche Praxis. *Dtsch Arch Klin Med*. 1905;83:363-406.
10. Sydorova NM, Sydorova LL, Bychkova SA. Clinical case of Gaisböck syndrome caused by hookah and tobacco smoking: "zebra" or "horse"? *Wiad Lek*. 2022;75(1, Part 2):324-326. doi:10.36740/WLek202201230
11. Sydorova N, Kazmirchuk K, Kolisnyk O, Tsaralunha V, Kobirnichenko Y, Sydorova L. Calculation of Integral Indicators of the Metabolic Status and Filtration Function of Kidneys in Patients with a Combat Mine-Explosive Injury who Lost Significant Body Weight due to Limb Amputation. *Acta Med Litu*. 2025;32(1):64-77. *doi:10.15388/Amed.2025.32.1.2*
12. Sydorova NM, Tsaralunha VM, Semenets OL, Letushko YI, Kovalenko VI, Kazmirchuk KA. Unresolved issues in the physician's management of a patient's therapeutic profile after limb amputation due to combat trauma: analysis of a clinical case. *Current Aspects of Military Medicine*. 2025;32(1):129-144. doi:10.32751/2310-4910-2025-32-1-11 [In Ukrainian]
13. Vereshchaka VV, Sydorova NM. Methodology for studying the hemomicrocirculatory bed of the bulbar conjunctiva at rest and during physical exertion. *Sports Medicine*. 2007;2:126-132. [In Ukrainian]
14. Vereshchaka VV, Sydorova NM, Kalyuzhna LD. *Clinical methods of hemomicrocirculatory system examination. Methodological recommendations of the Ministry of Health of Ukraine*. Kyiv; 2008. [In Ukrainian]
15. Stefanini M, Urbas JV, Urbas JE. Gaisböck's syndrome: its hematologic, biochemical and hormonal parameters. *Angiology*. 1978;29(7):520-533. doi:10.1177/000331977802900703
16. Krishnamoorthy P, Gopalakrishnan A, Mittal V, et al. Gaisböck syndrome (polycythemia and hypertension) revisited: results from the national inpatient sample database. *J Hypertens*. 2018;36(12):2420-2424. doi:10.1097/HJH.0000000000001805
17. Arber DA, Orazi A, Hasserjian R, et al. The 2016 revision to the World Health Organization classification of myeloid neoplasms and acute leukemia. *Blood*. 2016;127(20):2391-2405. doi:10.1182/blood-2016-03-643544
18. Martelli V, Carelli E, Tomlinson GA, et al. Prevalence of elevated hemoglobin and hematocrit levels in patients with obstructive sleep apnea and the impact of treatment with continuous positive airway pressure: a meta-analysis. *Hematology*. 2022;27(1):889-901. doi:10.1080/16078454.2022.2109346
19. Gangaraju R, Sundar KM, Song J, Prchal JT. Polycythemia Is Rarely Caused By Obstructive Sleep Apnea. *Blood*. 2016;128(22):2444. doi:10.1182/blood.V128.22.2444.2444
20. Zeng Z, Song Y, He X, et al. Obstructive Sleep Apnea is Associated with an Increased Prevalence of Polycythemia in Patients with Chronic Obstructive Pulmonary Disease. *Int J Chron Obstruct Pulmon Dis*. 2022;17:195-204. doi:10.2147/COPD.S338824

21. Vrints C, Andreotti F, Koskinas KC, et al. 2024 ESC Guidelines for the management of chronic coronary syndromes. *Eur Heart J*. 2024;45(36):3415-3537. doi:10.1093/eurheartj/ehae177
22. Tailor A, Cooper D, Granger DN. Platelet-vessel wall interactions in the microcirculation. *Microcirculation*. 2005;12(3):275-285. doi:10.1080/10739680590925691
23. Xiang M, Wu X, Jing H, et al. The impact of platelets on pulmonary microcirculation throughout COVID-19 and its persistent activating factors. *Front Immunol*. 2022;13:955654. doi:10.3389/fimmu.2022.955654
24. Odaka Y, Takahashi J, Tsuburaya R, et al. Plasma concentration of serotonin is a novel biomarker for coronary microvascular dysfunction in patients with suspected angina and unobstructive coronary arteries. *Eur Heart J*. 2017;38(7):489-496. doi:10.1093/eurheartj/ehw448
25. Lara-Castro C, Garvey WT. Intracellular lipid accumulation in liver and muscle and the insulin resistance syndrome. *Endocrinol Metab Clin North Am*. 2008;37(4):841-856. doi:10.1016/j.ecl.2008.09.002
26. Abumrad NA, Cabodevilla AG, Samovski D, Pietka T, Basu D, Goldberg IJ. Endothelial Cell Receptors in Tissue Lipid Uptake and Metabolism. *Circ Res*. 2021;128(3):433-450. doi:10.1161/CIRCRESAHA.120.318003