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Armored heart as an image of constrictive pericarditis - a review of the literature

Serce pancerne jako obraz zaciskającego zapalenia osierdzia – przegląd literatury

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Abstract:

Introduction: Pericarditis is diagnosed among 5% patients hospitalized due to chest pain. It is included in pericardial syndromes together with constrictive pericarditis, pericardial effusion and cardiac tamponade. There are many documented etiological factors leading to pericarditis, most commonly divided into infectious and non-infectious ones. The disease typically presents with chest pain, ECG changes, pericardial rub and pericardial effusion. The diagnosis is made with the results of parameters found in patients' blood and imaging tests. Treatment is usually based on pharmacological therapy, although in some cases the pericardial surgery is necessary. One of the characteristic changes in imaging diagnostics in patients with pericarditis is thickening of pericardial layers, the so-called armored heart.

Aim of the study: The aim of the study was to find clear diagnostic criteria for armored heart as a unique type of constrictive pericarditis.
Materials and methods: Articles available in the databases of medical publications: PubMed, Google Scholar, SCOPUS were analysed using the search phrase: armored heart* AND (pericarditis OR acute pericarditis).
Results: The search phrase was included in 18 records. After the initial verification, repetitive, unavailable and foreign papers were rejected. Finally, 3 manuscripts were included in further analyses. No clear criteria were found to classify constrictive pericarditis as an armored heart.
Conclusions: Armored heart is a 'subtype' of constrictive pericarditis. It seems that this term is used subjectively, based on imaging studies.
Keywords: armored heart, constrictive pericarditis

Wstęp: Zapalenie osierdzia to choroba diagnozowana u 5% pacjentów zgłaszających się z bólem w klatce piersiowej do szpitala. Zaliczane jest do tzw. zespołów osierdziowych razem z zaciskającym zapaleniem osierdzia, wysiękiem do worka osierdziowego i tamponadą serca. Istnieje wiele udokumentowanych czynników etiologicznych zapalenia osierdzia, które podzielono na zakaźne i niezakaźne. Choroba zazwyczaj manifestuje się bólem w klatce piersiowej, zmianami w EKG, tarciem osierdziowym i wysiękiem do jamy osierdzia. Diagnoza jest stawiana na podstawie wyników parametrów oznaczanych we krwi chorego oraz badaniach obrazowych. Leczenie zazwyczaj opiera się na farmakoterapii, zaś w pewnych sytuacjach konieczna jest chirurgiczne usunięcie osierdzia. Jednym z charakterystycznych zmian w diagnostyce obrazowej u chorych na zapalenie osierdzia jest tzw serce pancerne – czyli pogrubienie blaszek osierdzia.

Cel pracy: Celem pracy było odnalezienie jednoznacznych kryteriów diagnostycznych serca pancernego jako wyjątkowego typu zaciskającego zapalenia osierdzia.

Materiał i metoda: Analizie poddano artykuły dostępne w bazach publikacji medycznych: PubMed, Google Scholar, SCOPUS używając jako szukanej frazy: armored heart* AND (pericarditis OR acute pericarditis).

Wyniki: Odnaleziono 18 rekordów w których znaleziono szukaną frazę. Po wstępnej weryfikacji wyników odrzucono powtarzające się prace, oraz te których tekst był niedostępny w bazach publikacji medycznych oraz napisane w języku innym niż angielski. Ostatecznie do dalszych analiz włączono 3 manuskrypty. Nie znaleziono jasnych kryteriów na podstawie których zastosowano opisywano zaciskające zapalenie osierdzia jako serce pancerne.

Wnioski: Serce pancerne to „podtyp" zaciskającego zapalenia osierdzia. Wydaje się, że jest to określenie stosowane uznaniowo – subiektywnie, na podstawie badań obrazowych.

Introduction:

Acute pericarditis (AP) is an inflammation of the most inner serous membrane surrounding the heart (pericardium). Constrictive pericarditis is one of four possible pericardial syndromes, next to acute pericarditis, pericardial effusion and cardiac tamponade. These syndromes can be diagnosed using the 2010 Mayo Clinic criteria. [1] In some cases of pericarditis, the image of the heart and pericardium obtained in cardiac imaging is referred to as "an armored heart".
The incidence of acute pericarditis varies. According to studies, it ranges from 3.32 cases per 100,000 in the Finnish population to 27.7 cases per 100,000 in the Italian population. [2,3] Young men are predisposed to develop AP due to the influence of sex hormones, especially testosterone. [4,5] AP is estimated to affect approximately 0.1% of all hospitalized patients and 5% of patients hospitalized for non-coronary chest pain. [6]
The etiological factors causing all four pericardial syndromes mentioned above are divided into infectious and non-infectious types. It is widely recognized that inflammatory diseases of the pericardium can be caused by microorganisms such as enteroviruses, herpes viruses, adenoviruses and parvovirus B19. Viruses remain the primary cause of pericarditis in developed countries, while tuberculosis (*Mycobacterium species*) is the most common etiological factor in developing countries. Other bacteria, fungi and parasites cause pericardial disease rarely and very rarely, respectively. [7,8][Tab. S1]
Non-infectious factors include: autoimmune diseases, neoplastic diseases, metabolic diseases, post-traumatic changes, iatrogenic causes and drug-induced changes. Other reasons listed as frequent, not included in the above-mentioned factors include chronic heart failure, amyloidosis, pulmonary hypertension and dissecting aortic aneurysms. [8][Tab. S2]

Frequency of induction AP	Type of pathogen			
	Viruses	**Bacteria**	**Parasites**	**Fungi**
Common	• Enterowirusy: coxsackie, echo; • Wirusy herpes: EBV, CMV, HHV-6; • Adenowirusy; • Parvowirus B19	• Mycobacterium tuberculosis		
Rare		• Coxiella burnetii, • Borrelia burgdorferi, • Pneumococcus spp., • Meningococcus spp., • Gonococcus spp., • Streptococcus spp., • Staphylococcus spp., • Haemophilus spp., • Chlamydia spp., • Mycoplasma spp., • Legionella spp., • Leptospira spp., • Listeria spp., • Providencia stuartii		
Very rare			• Histoplasma spp., • Aspergillus spp., • Blastomyces spp., • Candida spp.	• Echinococcus spp., • Toxoplasma spp.

Table S1. Type of pathogens and frequency of induction of pericardial diseases.

	Common	Rare
Diseases of autoimmune etiology	Systemic autoimmune and auto-inflammatory diseases (systemic lupus erythematosus, Sjögren syndrome, rheumatoid arthritis, scleroderma), systemic vasculitides (i.e. eosinophilic granulomatosis with polyangiitis or allergic granulomatosis, previously named Churg-Strauss syndrome, Horton disease, Takayasu disease, Behçet syndrome), sarcoidosis, familial Mediterranean fever, inflammatory bowel diseases, Still disease.	
Cancer diseases	Secondary metastatic tumours (common, above all lung and breast cancer, lymphoma).	Primary tumours (rare, above all pericardial mesothelioma).
Metabolic diseases	Uraemia, myxoedema, anorexia nervosa, other rare.	
Post-traumatic lesions and iatrogenic disorders	Delayed onset: Pericardial injury syndromes (common) such as postmyocardial infarction syndrome, postpericardiotomy syndrome, posttraumatic, including forms after iatrogenic trauma (e.g. coronary percutaneous intervention, pacemaker lead insertion and radiofrequency ablation).	Early onset: Direct injury (penetrating thoracic injury, aesophageal perforation). Indirect injury (non-penetrating thoracic injury, radiation injury).
Drug changes		Lupus-like syndrome (procainamide, hydralazine,

		methyldopa, isoniazid, phenytoin); antineoplastic drugs (often associated with a cardiomyopathy, may cause a pericardiopathy): doxorubicin, daunorubicin, cytosine arabinoside, 5-fluorouracile, cyclophosphamide, penicillin as hypersensitivity pericarditis with eosinophilia; amiodarone, methysergide, mesalazine, clozapine, minoxidil, dantrolene, practolol, phenylbutazone, thiazides, streptomycin, thiouracils, streptokinase, p-aminosalicylic acid, sulfa-drugs, cyclosporine, bromocriptine, several vaccines, GM-CSF, anti-TNF agents.
Other reasons	Amyloidosis, aortic dissection, pulmonary arterial hypertension and chronic heart failure.	Congenital partial and complete absence of the pericardium. CMV.

Table S2. Non-infectious factors causing pericardial diseases.

Symptoms of pericarditis and criteria for diagnosis:

Clinically, pericarditis is most often manifested by chest pain, shortness of breath, fever, a slightly faster heart rate and pericardial rub. In imaging diagnostics pericardial and pleural effusion become noticeable, while in laboratory tests results show leukocytosis and often increase in CRP, ESR, troponin and creatine kinase. Patients most commonly report symptoms such as chest pain and fever. [4,5]

The diagnosis of pericarditis consists upon the confirmation of at least 2 out of 4 of the following symptoms:

1. Localized, pericardial pain in the chest,

2. Pericardial rub,
3. Newly detected ST elevation or PR depression on a multi-lead ECG,
4. Pericardial fluid (previously absent or increase in the volume of fluid previously present).
The laboratory parameters mentioned earlier, such as an increase in CRP, ESR, leukocytosis may be helpful in the diagnosis, as well as the results of imaging tests, such as CT, MRI, chest X-ray and echocardiography. [9]

Constrictive pericarditis may be suspected when the patient has a history of dyspnoea, fatigue and sometimes palpitations. Physical examination may capture increased pressure in the jugular veins, Kussmaul's phenomenon, peripheral oedema, pulsating and enlarged liver, pleural effusion and ascites. Additional tests show non-specific changes in the ST segment and T wave and chest X-ray shows pericardial calcifications.
The diagnosis of constrictive pericarditis may also be supported by the following features in echocardiography: enlargement of both atria, respiratory variability of the interventricular septum, respiratory variability of the mitral inflow velocity, preserved or increased velocity of the mitral annulus, flow reversal in the hepatic veins (more visible during expiration). These are specific to constrictive pericarditis and allow to make a diagnosis. Thickening of the pericardium, dilatation of the inferior vena cava, enlargement of both atria occurring in constrictive pericarditis are also characteristic of dilated cardiomyopathy, therefore they cannot be used for diagnostic purposes. [10]
Symptoms that may occur in both constrictive pericarditis and restrictive cardiomyopathy are: increased pressure in the atria, equalization of end-diastolic pressures, a sharp drop and plateau of diastolic *square root sign.* In addition to the above mentioned, the further changes found in the study support constriction, such as increased dependence of the ventricles respiratory variability of ventricular filling and inconsistent changes in systolic pressure in the left and right ventricle during breathing. Many of the above parameters can be measured by ECHO. In the case of an unclear picture, cardiac catheterization is the decisive test. [10]
Treatment of inflammatory diseases of the pericardium is based on two strategies - pharmacotherapy and surgical removal of the pericardium.
The basis of treatment of inflammatory diseases of the pericardium is pharmacotherapy, especially in acute, newly diagnosed cases. It seems to be extremely important in the case of tuberculous inflammation, as it can rapidly generate constrictive pericarditis. There is clear data marking the importance of pharmacological treatment in such cases. Prompt

implementation of antibiotic therapy reduces the risk of disease progression to less than 10% [11-13].

Anti-inflammatory therapy also reduces pericardial constriction. Such changes are observed in about 10-20% of patients and its usage allows to avoid pericardiectomy. [1,14-16] The last important aspect of pharmacological treatment is the reduction of symptoms of congestive heart failure in the course of pericarditis, especially in patients with contraindications to surgical treatment. [1] Surgical treatment involving the removal of the pericardium is the basis for the treatment of persistent lesions. [4]

Aim of the study:

The aim of the paper is to present the problem of the armored heart, which is a special type of constrictive pericarditis belonging to pericardial syndromes. The relatively rare occurrence of such image may cause difficulties in diagnosing patients such features in imaging studies. An additional aim of the study was to check whether the term '*armored heart*' itself is a clinical diagnosis or a subjective term. If such recognition is confirmed, the authors of this manuscript wanted to identify and highlight official diagnostic criteria.

Materials and methods:

Three teams consisting of 2 authors each searched the databases of medical publications. Articles available in the databases of medical publications: PubMed, Google Scholar, SCOPUS were retrospectively analyzed using the search phrase: armored heart* AND (pericarditis OR acute pericarditis).

The outcome of the work of all 3 teams was confronted to one another and the final list of articles was selected for further analysis. As a result of the search in the databases of medical publications, many articles were found containing the searched keywords in the title, abstract and text of the publication. 18 records were found that matched all search criteria. Repetitive articles and those manuscripts whose text was not available in medical publication databases were rejected. Articles written in foreign languages were denied as well. Ultimately, three scientific papers were qualified for the next stage of editing the article, all of which were clinical case reports. The search results are presented in the table. [Tab. S3]

Author (year)	Type of article (number of patients)	Age/ sex	Etiology	Concomitant diseases/ Medical history	Symptoms	Further fate of the patients
Uchi, T. (2019) [17]	Case report (1)	72/M	*M. tuberculosis*	Diabetes mellitus, Hypertension, Dyslipidemia	Fever, Dyspnea, Infiltrative shadow in the right upper lobe of the lungs on chest X-ray.	-
Velthuis, S. (2009) [18]	Case report (1)	66/M	Myocardial infarction and pericardial surgery	Anterior myocardial infarction with myocardial rupture, with cardiosurgery intervention	Ascites Peripheral edema	Death
Warburg, E. (1954) [19]	Case report (1)	42/M	Injury	-	Inverted T I Leads I, II, III, V_5-V_6	-

Tabela S3. Search results. **M** – male, **F** – female.

Discussion:

In 2019, the results of research conducted on a group of patients from the USA with constrictive pericarditis were published. Study group consisted of 29,487 patients. It was established that in the years 2005-2014 the number of patients hospitalized due to constrictive inflammation was stable at 9-10 cases per million people; in 84% the basis of treatment was pharmacotherapy, the remaining 16% underwent pericardiectomy. However, there was a declining trend in the number of patients treated surgically from 18% in 2005 to 15% in 2014.

[20] As a consequence of conservative treatment, it is possible to achieve higher patient survival because, as studies show, removal of the pericardium is associated with a poor prognosis and mortality estimated at 6 - 10%. [21-24]

According to the literature reviewed in this article, each study was related to men. This is consistent with the general statistics clearly showing a higher incidence of AP in men aged 16-65. The lack of description of clinical cases describing pericarditis in women seems to be just a matter of chance and is not the basis for drawing far-reaching conclusions about the incidence of pericarditis depending on gender. As mentioned earlier, the greater development of inflammation in men compared to women is due to the influence of testosterone, other hormones and mediators released from the testicles. [4,5] As demonstrated in mice studies, the explanation lies in the inhibition of anti-inflammatory cells produced by male sex hormones. [25,26] It seems quite surprising that no cases have been found describing the armored heart in young adults - the social group most predisposed to developing pericarditis. [5]

Tuberculous pericarditis is associated pericardial cavity effusion containing various substances that contribute to the inflammatory process. In the process of healing the inflammation, scars and calcifications can be formed and lead to impaired diastolic function of the heart. As a consequence, the organ becomes stiffened by the fibrotic pericardium and constrictive pericarditis starts to emerge. It seems to be interesting that in people with tuberculosis coexisting with HIV numer of cases with pericardial effusion and constriction is lower than in people only with tuberculosis without the coincidence of a viral disease. According to research, this is related to smaller number of CD41 lymphocytes that are responsible for the formation of granulomas in people with HIV infection. [27]

Interestingly, in one case report constrictive pericarditis developed in a patient with a history of acute coronary syndrome complicated by myocardial rupture and cardiac surgery undergone several years earlier. [18] Most post-infarction pericarditis occurs shortly after the infarction, in about 1-2 weeks; on the other hand, Dressler's syndrome (late post-infarction pericarditis) occurs in <1% of patients after myocardial infarction and routinely affects people with delayed coronary intervention or with extensive infarction. [28] In the given example of the case, the patient had a massive anterior myocardial infarction and a heart wall rupture, resulting in pericardial haemorrhage, both of which are independent predictors of pericarditis. [29-31] Warburg et al reported a similar clinical case of a patient who developed constrictive pericarditis due to trauma and subsequent bleeding into the pericardial cavity. [19]

No clear criteria were found on the basis of which the authors of cited studies operated with the term "armored heart". During the analysis of the literature, the authors came to conclusions the phrase is a subjective one, describing characteristics found in imaging tests.

Conclusions:

Pharmacotherapy effectively reduces mortality in pericarditis and shows advantage over surgical treatment. However, in the case of clear indications for pericardiectomy, abandonment of surgery reduces the chance of survival. Armored heart is not a separate diagnosis – the term describes constrictive pericarditis with a characteristic image of thickened pericardial plaques in imaging studies.

There are no diagnostic criteria to clearly distinguish the image of an armored heart from the results of imaging tests in patients with constrictive pericarditis. The phrase remains subjective, describing characteristic changes seen in imaging studies in patients with constrictive pericarditis.

Supplementary Materials: Table S1: Type of pathogens and frequency of induction of pericardial diseases. Table S2: Non-infectious factors causing pericardial diseases. Tabela S3: search results. **M** – male, **F** – female.

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