

Helmet Sign on EKG: A Rare Indicator of Poor Prognosis in Critically Ill Patients

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Abstract Background: The ‘Spiked Helmet’ is an electrocardiogram (EKG) finding occasionally seen in critically ill patients characterized by ST segment elevation usually represented as a ‘spike and dome’ pattern with elevation in the EKG baseline prior to the R wave and adjoining ST segment elevation resembling the German military helmet of the Prussian Empire. In the few cases reported in literature, this finding has been associated with very poor clinical outcomes, including in-hospital death. Although ST elevation is not uncommon in critically ill patients, these findings of a ‘Spiked Helmet’ sign are often transient and typically not associated with acute coronary syndrome. **Case presentation:** A 56-year-old male was found unresponsive by his relatives at home. It was unknown the time that he had been unconscious. When the emergency medical services arrived, patient was found to be in pulseless electrical activity (PEA). Patient achieved return to spontaneous circulation (ROSC) 15 minutes after initiation of advanced cardiac life support protocol. An electrocardiogram done immediately post ROSC showed ST elevations in inferior and lateral leads. Patient was brought to the hospital as a ST elevated myocardial infarction (STEMI) arrest. The EKG revealed the Helmet sign in leads aVL and II, also ST segment elevation was noted in V1, V2, V3 and ST segment depression was noted in V5 and V6. Troponin was negative at the time of initial evaluation but trended up gradually during the hospitalization. A computed tomography (CT) pulmonary angiogram was negative for pulmonary embolism. A head CT showed diffuse anoxic brain injury. Patient was started on the hypothermia protocol. Upon family request patient was terminally extubated two days into hospital stay and expired shortly after. **Conclusion:** Although we are yet to fully understand the significance of the ‘Spiked Helmet’ Sign, this case report and literature review offers a comprehensive overview of the reported cases and draws important links and clues from them.

Keywords: helmet sign, EKG, critically ill, STEMI, poor prognosis

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1. Introduction

Electrocardiographic findings undeniably hold major clues to identifying causes of acute patient decompensation. An occasional electrocardiography (EKG) finding in critically ill patients, with very few cases reported in literature, is the ‘Spiked Helmet’ (SH) Sign or the ‘Helmet’ Sign. The Helmet sign is a transient ST- elevation with characteristic spike and dome pattern with elevation in the EKG baseline prior to the QRS with adjoining ST segment elevation. The pattern in this EKG finding resembles the German military helmet of the Prussian empire, hence the

name. In many of the cases of such ST elevation in critically ill patients it has been shown that a sizable amount often is as a result of causes other than acute coronary syndrome [1,2]. The helmet sign seen in critically ill patients often indicate very poor prognosis and often a sign of impending doom. Here, we present a case of helmet-sign seen in a patient post cardiac arrest.

2. Case Presentation

We present a case of a 56-year-old male with medical history of hypertension and hyperlipidemia who was found on the floor by his spouse unresponsive and not

breathing in the early hours of the morning. The last-known-well was the night prior. There was no clear estimate of duration of events. Upon arrival of Emergency medical services, patient was found to be in pulseless electrical activity (PEA). Patient achieved return to spontaneous circulation (ROSC) 15 minutes after initiation of advanced cardiac life support (ACLS) protocol. Patient received 3 doses of Epinephrine, 2 doses of Bicarbonate and 1 dose of Calcium. EKG done immediately post ROSC showed ST elevations in inferior and lateral leads. Patient was brought to the hospital as a STEMI arrest. A detailed analysis of the EKG revealed helmet sign in leads aVL and II, also ST segment elevation was noted in V1, V2, V3 and ST segment depression was noted in V5 and V6. Bedside echocardiogram obtained showed no wall motion abnormalities and repeat EKG including with right sided leads revealed no ST segment elevation with no accompanying pathologic Q waves or T-wave inversion. Troponin was negative at the time of initial evaluation but trended up gradually during hospitalization. Laboratory results were also notable for creatinine of 3.07 and CPK 457 in addition to mildly elevated White blood cell count and elevated aspartate aminotransferase, alanine aminotransferase, and lactate most likely as a result of tissue hypoperfusion due to the cardiac arrest. CT scan angiography of the chest was negative for pulmonary embolism. A head CT without contrast showed diffuse anoxic brain injury. Patient was started on hypothermia protocol. Official Echocardiography obtained later the same day of presentation showed an increase in right ventricle size in the upper limit of normal and a reduced right ventricular ejection fraction. Estimated peak pulmonary artery pressure was 35 – 45 mm hg. Left ventricular ejection fraction was estimated to be between 45% – 55% with no regional wall motion abnormalities. Mild concentric hypertrophy was also noted in the left ventricle. Doppler parameters were consistent with abnormal ventricular relaxation and no valvular abnormalities were noted. Patient remained intubated with continuous vasopressor support. Upon family request, patient was terminally extubated two days into hospital stay and expired shortly after.

3. Discussion

The first examples of the Helmet sign on EKGs were described in a case series of about 8 patients [3]. Several explanations for the appearance of this abnormal EKG findings include pulsatile contraction of the diaphragm in sync with the cardiac cycle [4,5] and other mechanisms of diaphragmatic activities including abnormal breathing patterns with unexplained respiratory artifacts [6] or repetitive epidermal stretch due to acute increase in intra-abdominal or intrathoracic pressures [7,8]. These findings often indicate the need to rule out acutely evolving events in the chest or the abdomen [9]. These EKG findings have also been known to commonly occur in the inferior leads and in which case, may point strongly to an acute abdomen. Additionally, the presence of these EKG findings in the precordial leads may be more

suggestive of acute rise in intrathoracic pressure with causes such as an aortic dissection, pneumothorax, pneumomediastinum or acute respiratory distress syndrome [7,8,9,10]. A link between phrenic nerve stimulation and the baroreceptor reflex has also been suggested to play a role in the presence of synchrony between diaphragmatic contractions and ventricular contractions [5]. Stretch induced by cation channels have also been postulated to play a role in the underlying physiology of these EKG findings as a result of diaphragmatic movements [11,12]. It is also possible to suggest that electrical activity of the skeletal muscle of the diaphragm contracting in sync with the cardiac cycle may be represented on the EKG as cardiac activity. This latter suggestion also draws a link between acute intrathoracic events and intra-abdominal events being some of the more likely causes of the spiked helmet sign as a result of abnormal diaphragmatic contractions that may be seen in both. Aggressive resuscitation efforts including mechanical ventilation may also play a role in increased intrathoracic pressure. Acute intra-abdominal events that may increase pressures include intestinal ileus or perforation with free air under the diaphragm.

Because of the rarity of these EKG findings and evaluate other causes of ST elevation in the EKG in acutely ill patients, it is important to clearly differentiate this presentation from an acute coronary syndrome. Particularly so, because of the time sensitive intervention that is required in the management of acute coronary syndromes. Several reports have highlighted the presence of ST- elevation in the EKGs of acutely ill patients. It is important to note that majority of these ST-segment elevations were not associated with acute coronary disease [1,2]. Common causes of acute ST-segment elevation that may be found in critically ill patients include early repolarization abnormalities, left ventricular hypertrophy, left bundle branch block, acute pericarditis, hyperkalemia, Brugada syndrome, pulmonary embolism, Prinzmetal angina, and in patient who were recently cardioverted. Some ST segment elevations are considered normal variants, for example, those seen in young men with concave elevation of 1-3mm most notable in V2 [1].

Several factors that support the uniqueness of the 'Spiked Helmet' (SH) sign includes the presence of an upward shift in the EKG baseline before the QRS segment in addition to the adjoining ST- segment elevation giving the characteristic German/Prussian military helmet shape. This unique pattern of the SH sign is most suggestive of etiologies other than true repolarization defects [1] that would have been otherwise suggestive of acute ischemia of the myocardium. Other noteworthy factors include the degree of troponin elevation [2] with studies showing that a peak troponin elevation of less than 5 may reliably rule out acute ST segment elevation myocardial infarction in these critically ill patients. It is worth noting however that elevated troponin in critically ill patients with or without confirmed acute coronary syndromes is associated with poor prognosis [13]. It is important to note here that our patient had a peak troponin of 4.58, twenty-four hours after initial resuscitation.

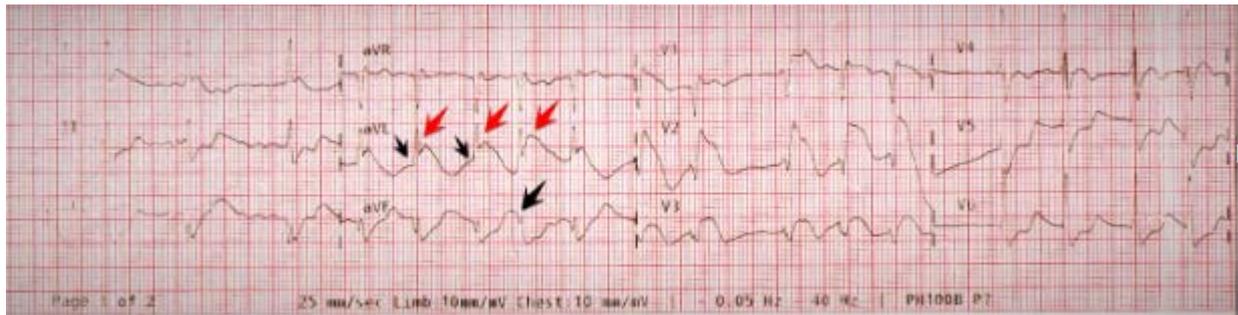


Figure 1. An electrocardiographic strip showing the elevation in the EKG baseline prior to the QRS with adjoining ST segment elevation more prominent here in AVL. The red arrows represent the ST-segment elevation and the black arrows represent the pre-QRS elevation from baseline: ‘Spiked Helmet Sign’

Another important observation in this case is the disappearance of the ST–segment elevation on repeat EKG without the characteristic evolution noted in ischemic heart disease usually featuring the appearance of inverted T-waves and appearance of Q waves. This has been reported in some of the case reports which further indicates the absence of a true repolarization abnormality [7,9].

Review of similar cases in literature some important similarities including the high number of in-hospital deaths evolving rather rapidly following this EKG finding. At the time of the EKG findings, many of the patients were on mechanical ventilators and critically ill. As mentioned earlier, some of the cases were associated with intrathoracic pathologies such as, pneumothorax, aortic dissection or acute abdomen likely due to intestinal ileus or perforation. It is however important to note, that some cases of ‘Spiked Helmet’ signs were seen in patients with rather unique diagnosis such as Takotsubo cardiomyopathy and long QT syndrome [14,15]. In the case of Takotsubo cardiomyopathy, a presumptive diagnosis was made without a cardiac catheterization based on the presence of ST elevation in the form of a ‘Spiked Helmet’ sign in the inferior and anteroseptal leads that was accompanied by ST-segment depression in the AVR [16]. Another

suggestion by Aliyev et al about an underlying sympathetic surge only further supports the link between the spiked helmet sign and diagnosis such as ventricular tachycardias and Takotsubo cardiomyopathy and perhaps in other cases due to the stress of the illness.

Looking at the transthoracic echocardiography report in retrospect, it is very likely that the reduction in right ventricular systolic function and elevated pulmonary artery pressure, may have been clues to our patient’s acute condition adding acute right heart syndrome to our differential; although, the absence of pulmonary embolism on CT scan angiography of the chest makes this diagnosis less likely.

The degree of troponin elevation and spontaneous resolution of the ST- segment elevation in our opinion also ruled out right ventricular infarction. The absence of characteristic signs of acute respiratory distress syndrome on radiographs and CT scan as well as, the absence of physical examination findings suggestive of right ventricular failure, rules out that possibility, leaving us to postulate that the right ventricular systolic dysfunction would most likely have been as the result of the mechanical ventilation failure [17]. Table 1 lists cases of ‘Spiked Helmet’ signs reported in literature [3,18-23].

Table 1. A collection of cases of the ‘Spiked Helmet’ sign reported in the literature thus far. Full spreadsheet and references can be found below

Year of publication, author	Age in years	Sex	Clinical condition
2011, Littman et al. [3]	58	Female	Bowel perforation and ischemia, sepsis, shock
	46	Male	Pneumonia, sepsis, hypothermia, diabetic ketoacidosis, acute renal failure, respiratory failure
	54	Female	end stage renal disease, peripheral arterial disease, cellulitis, sepsis
	71	Female	Amyotrophic lateral sclerosis, respiratory failure, altered mental status, fever, diarrhea, VAP, empyema
	22s	Male	Trauma, sepsis, cardiac tamponade, anoxic brain damage, seizure
	44	Male	Nonischemic dilated cardiomyopathy, cardiac arrest, anoxic brain injury, sepsis, deep vein thrombosis, acute renal failure, seizures
	66	Male	Subdural and subarachnoid hemorrhage, anoxic brain damage
	55	Female	Acquired immunodeficiency syndrome, pneumocystis carinii pneumonia, respiratory failure, Pneumothorax
2014, Aggarwal et al. [18]	77	Male	Rhabdomyolysis
2014, Tomcsányi et al. [19]	83	Female	Sepsis
	56	Female	Respiratory distress
2014, Littmann et al. [20]	73	Male	Respiratory distress, pneumothorax
2016, Namana et al. [21]	90	Male	New Onset Seizure
2017, Farid et al. [22]	35	Female	Polymorphic ventricular tachycardia post renal transplantation
2018, Samadov et al. [23]	72	Male	Upper gastrointestinal bleeding, sepsis
2019, Oluyadi et al.	56	Male	Cardiac arrest



Figure 2. The helmet sign is named after Prussian helmet shown in the image [24]

4. Conclusion

Differentiating between acute coronary syndromes and other phenomena, such as type 2 demand ischemia, still remains a common occurrence in critical care settings. In this case, an ST segment elevation in critically-ill patients presents a unique problem in identifying the particular etiology of the EKG findings. The 'Spiked Helmet' sign has been reported is one of such ST segment elevation whose etiology is not directly linked to an acute coronary process but is increasingly seen in critically ill patients with impending deterioration. Therefore, it is important to rule out possible causes of this finding for example evolving conditions associated with an increasing intrathoracic pressure or and increasing intra-abdominal pressure. We hereby recommend further research into the significance and clinical characteristics of 'Spiked Helmet' sign.

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