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Review article

**The Causes of Jesus' Death in the Light of the Holy Bible and the Turin Shroud**

Abstract

Due to the lack of information, the pathogenesis of the death of Jesus of Nazareth is still widely debated. A univocal pathogenesis can be detected by the close comparison between what is reported in the Holy Bible (in particular the four Gospels and the prophetic passages of the Old Testament) and what can be observed on the Turin Shroud (TS). Obviously the authenticity of the latter must be here accepted in the sense that it wrapped the corpse of Jesus of Nazareth.

The criteria used to support or ignore many etiological hypotheses regarding the terminal event that caused Jesus' death must take into account: an acute fact, the perfect lucidity and the cry of Jesus immediately before his death. We conclude that the causes of death are:

**Terminal cause:** myocardial infarction, heart rupture and hemopericardium.

**Contributing and accelerating causes, in chronological order:** 1. severe emotional stress and sweating with hematothrosis, 2. fluid loss without drinking, 3. beating and scourging, 4. crown of thorns, 5. blunt trauma to the neck and thorax following the fall with right shoulder dislocation, paralysis of the entire right brachial plexus, pulmonary contusion with hemothorax and cardiac contusion, 6. nailing, 7. probable left ulnar proximal paralysis from stretching during crucifixion, 8. probable right foot dislocation from stretching during crucifixion, 9. causalgia, 10. Hypoventilation, 11. Hemorrhagic-hypovolemic-politraumatic and suspension shock.

Introduction

This paper aims at answering the following question: from a medical point of view, how did Jesus of Nazareth die? This is not a simple question because the sources describing this death are very limited.

On the one hand there is the Holy Bible, in particular the four Gospels and the prophetic passages of the Old Testament that describe Jesus' death principally from a religious point of view, including interesting clues that may be interpreted from a medical point of view.

On the other hand there is the TS that contains a lot of scientific information about Jesus' death but this information is not always simple to interpret from a scientific point of view.

The TS [1-4], see Figure 1, is linen cloth, 4.4 m long and 1.1 m wide, showing the double image of a dead man that was scourged, thorn-crowned, stabbed in the side and crucified. The human image which is permanently impressed on the TS cannot be explained by science nor can it be reproduced [5].

The TS is believed by many to be the burial cloth in which

Jesus Christ was wrapped about 2000 years ago [6]. On the contrary others think that it is the result of an artist's work. There are some indications [7] that the TS was in Palestine

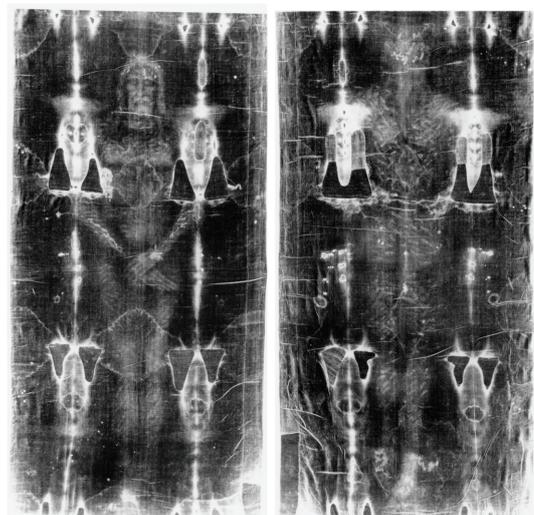


Figure 1: Negative image of the TS, front and back.

in the first century A.D. and then taken to Edessa (current Sanliurfa in Turkey). The coincidence of the TS face with that of Christ on Byzantine coins (especially the golden solidi), distributed in the VII century A.D., demonstrates that the TS was known during the Byzantine empire [6].

After the Sack of Constantinople in 1204 the “Shroud of Christ” appeared in Europe in 1353 at Lirey in France [7] and it was fire damaged in 1532, at Chambéry in France. In 1988 the linen fabric was radiocarbon dated to the middle Ages [8], but debates arose on this result. In fact, there are some works that try to explain the debatable TS dating of 1988 by considering the possible presence of systematic errors, as shown in a copious statistical analysis by Riani et al. [9]. More recently other authors dated the TS in a period compatible with the epoch when Jesus lived in Palestine [10,11].

After the results of recent studies [12,13] that confirm the many correspondences between the new findings of the TS with what is described in the Christian Holy Bible, the authors consider that Jesus of Nazareth is the Man of the TS.

The authors believe in authenticity of the TS. The sources of information in their hands are those coming from the TS, the four Gospels and the prophetic passages of the Old Testament. Therefore, this paper bases the scientific discussion of the causes of Jesus death on the following hypotheses:

1. The TS is the funeral sheet used for the burial of Jesus of Nazareth simply called Jesus.
2. The Christian Holy Bible [14] is credible and narrates the history of Jesus.

The criteria used to support or ignore the many etiological hypotheses regarding the terminal event that caused Jesus' death that must have been an acute fact, is to examine each hypothesis in the light of information coming from these sources.

As a perfect agreement was found, the authors use both the information coming from the Holy Bible and the TS to try to understand what the cause of Jesus' death was.

## Information from the Holy Bible

### From the old testament

Several passages are found in the Old Testament in reference to both the physical and moral state of the Saviour.

Isaiah foresaw that every part of the Saviour's body would be wounded and/or bruised (Is 1,6), in particular the whole head would be injured (Is 1,5) and the back would be wounded by the executioners (Is 50,6). Also the Psalms foresee that the plowers plowed upon the Just Man's back (Ps 129,3).

The same Psalms indicate the state of Christ during crucifixion; both his feet and hands were pierced (Ps 22,17-18), he was thirsty (Ps 69,4), and therefore he was given vinegar (Sal 69,22); his heart had become like wax melting away within his chest (Sal 22,15). This last point was also confirmed by

Isaiah (Is 1,5). In accordance with Exodus we also see that no bone was broken (Ex 12,46). Zacharias add that he was pierced [by a lance] (Zc 12,10) and Ezekiel that some “water” flowed out from that wound (Ez 47, 1).

In reference to the moral pains of Jesus the Psalms indicate that the Saviour would suffer shame (Ps 69,8) and insults that would break his heart (Ps 69,21). Isaiah concludes that Christ would be wounded for our offenses and crushed for our sins (Is 53,5).

### From the new testament

Several passages are quoted in the New Testament in reference to Jesus' Passion.

Jesus had a non-negligible blood loss by blood sweating (Lk 22,44), scourging (Jn 19,1), crown of thorns (Jn 19,2), nailing (Jn 20,25-28).

During the crucifixion, Jesus had the strength to cry out to the Father (Mt 27,50) just an instant before his death.

In addition, despite the state of extreme physical pain, his mind was perfectly lucid until his death (“When Jesus had taken the wine, he said “It is finished”, and bowing his head, he gave up the spirit”) (Jn 19,30).

The soldier, seeing that he was already dead, did not break his legs (Jn 19,33) but thrust his lance into his side, and immediately blood and water flowed out (Jn 19,34).

## Information from The TS

The morphological characteristics of the TS Man (Figure 2) and the many bloodstains present on the TS testify the hard tortures imposed on Jesus and confirm the sufferings described by the Gospels with the addition of many details, for example: fracture of the nasal septum (by beating?); more than 370 wounds by scourging [3]; cuts and bruises on his shoulders more clear on the outer side of the right suprascapular region



Figure 2: Jesus' face from the TS.

and, lower, on the left scapular region; excoriations, clearer on the right knee; presence of the typical soil of Jerusalem on His knees and on His nose, indicate a fall; the bleeding for the scourging, the crown of thorns, (Figure 2), the nailing; the post mortem “blood and water” spilled from the chest after the lance.

Recent studies on the TS [12,13] show the traumatic events suffered by Jesus that are summarized here.

1. A right humerus underglenoidal dislocation of about 3 cm is present.
2. The right shoulder is lowered by about 15° compared to the left.
3. The fingers of his right hand are outstretched resting on the left thigh, not flexed as on the left one.
4. It is very likely that there is also a right enophthalmos.
5. The alterations No. 1-4 lead to the hypothesis that Jesus fell violently to the ground under the weight of the cross (60 ± 20 kg) and reported a very critical blunt trauma to the shoulder, neck and chest with humerus dislocation, paralysis of the entire brachial plexus and the cervical sympathetic. For this reason the Roman soldiers were forced to command another man (Simon from Cyrene) [Lk 23,26, Mk 15,21] to carry His cross.
6. The heavy fall and/or flagellation may have caused a pulmonary contusion with hemothorax and, likely cardiac contusion. This could explain the abundant flow of *blood and water* from the chest when the spear was thrust after death, and may support the hypothesis of death from myocardial infarction (see below).
7. The thumbs prints are lacking. This is linked to the trauma by nailing, probably made in the wrists in the Destot's space, between lunate/pyramidal and capitate/uncinate, with clean break of the ulnar artery and excitation of ulnar nerve fibers that innervate the flexor pollicis brevis and adductor pollicis muscles [15].
8. The faint print of the right toes, with the shroud resting on the stone floor, not tied, suggesting a dislocated right ankle.
9. Despite the state of extreme physical pain, one can admire the majestic solemnity and serenity of the face, as a proof of perfect lucidity and self-control immediately before death.

## The Psychophysical State of Jesus

### The psychical state

Jesus suffered a constant state of severe emotional stress and depression that began in the Garden with a panic attack [Lk 20,39-46] and then for the tortures and derision, the slaps and spits of the soldiers and the crowd, until the end culminated in his invocation to the Father (“My God, my God, why have you

forsaken me?” Mk 15,34). In this condition, his heart certainly suffered from vasoconstriction. Malantruccio [16] speculates that already in Gethsemane Jesus had a myocardial infarction and at the end, at the ninth hour of the next day, His heart was broken, with the hemopericardium, and he gave out a loud cry.

Jesus was very thirsty because we think he had not drunk anything for eighteen hours. He had lost fluids by sweating that begun in the Olive Garden with hematohydrosis and by all subsequent events such as pain from multiple trauma, physical fatigue on the road, beatings, physical effort carrying the cross and struggling breathe on the cross.

### The physical state

The brutal scourging with the flagrum produces a loss of blood and, to a lesser degree, the extreme sweating and the beating at the home of Caiaphas, propelled Jesus into an early stage of shock [17].

The physical effects of the crown of thorns are the profuse bleeding, which reduced him to a mask of blood and kept him from sight, and a terrible unbearable trigeminal neuralgia caused by the many shoves and blows by the soldiers would be felt at every movement and impact of the head against the cross, with the falls and during the undressing before the crucifixion on Golgotha.

His shoulders were traumatized from carrying the heavy cross and falling several times. When Jesus reached Calvary, he must have been extremely exhausted to the point of fainting and having difficulty keeping his balance. It is safe to assume that he was in a moderate state of shock at his arrival on Calvary caused by traumas to the neck, shoulder and chest, with his dislocated and paralyzed right arm, and by trigeminal neuralgia; from dehydration due to the slow blood accumulation into right pleural cavity (hemothorax) and the excessive sweating.

Jesus on the cross certainly suffered a very serious and widespread causalgia (burning pain and shock at the tiniest movements) due to nerve injuries produced by the nails to the upper left limb and lower limbs and also to the paralysis of the upper right limb (paradoxical causalgia).

## Hypotheses Regarding the Terminal Event That Caused Jesus' Death

Presumably Jesus was crucified and hoisted on to the cross just before noon, after the sixth hour according to the roman calendar [Jn 19,14].

The procedure of nailing was quite complicated considering that the right upper limb was dislocated, the left upper limb was probably violently stretched and perhaps also the right ankle was dislocated by pulling it, probably to drive the nails in pre-drilled holes on the wood.

The agony begun immediately after until the ninth hour (around three pm), when the earth darkened [Mt 27,45; Mk 15,33; Lk 23,44].

He was in a constant struggle to breathe and not to lose consciousness, relying especially on his feet fixed together by only one nail. In fact, His right arm was paralyzed and the left one had been pulled. All this despite the excruciating pain from *causalgia*.

Despite the savage massacre suffered, humanly unbearable, and the extreme physical and psychic pain, Jesus remained alive at least three hours after the crucifixion and, even more incredibly, self-controlled to the end.

Perhaps more important than these physical pains was the moral pain of Jesus in seeing that all his struggles were vain for a lot of persons around him continued to mock him. This kind of psychological pain certainly had an influence on the state of his heart (“Insult has broken my heart”) (Ps 69,21).

The death occurred immediately after His cry, which suggests that it must have been caused by a supervening cause acutely manifested in the terminal phase of the agony. If so, other conditions must be considered only factors that contributed to extreme the passion of Jesus.

In the light of these considerations, we will discuss the main hypotheses formulated on Christ death:

- Ventilatory failure
- Hypovolemic traumatic shock
- Orthostatic syncope and cardiac arrest from suspension
- Pulmonary thromboembolism
- Trauma-induced coagulopathy
- Multifactorial hypotheses
- Blunt chest injury: pulmonary contusion, hemothorax, cardiac contusion
- Myocardial infarction, heart rupture and hemopericardium

## Discussion of Hypotheses Highly Unlikely with the Gospel Account

### Ventilatory failure, with severe hypoxemia and hypercapnia up to asphyxia

The ventilatory failure is the inability to ensure adequate pulmonary gas exchange, resulting in hypoxemia and hypercapnia. Hypoxemia is a reduction of oxygen; hypercapnia is an increase of carbon dioxide in arterial blood.

Acute respiratory failure is characterized by hypoventilation with short and slowed down breaths, bronchial hypersecretion, sweating, speech and ideation slowness, agitation and anxiety (stage I), cyanosis, and increasing drowsiness (stage II), loss of consciousness and coma with areflexia, cardio-circulatory collapse (stage III), and finally cardiac arrest.

The hypothesis of asphyxia is supported by Barbet [18],

conforming with the conjecture of Dr. Le Bec in 1925 on the death by crucifixion [19] and the testimony of Hynek [20], regarding severe punishment practised among the Austro-German military forces during the World War I and those of two veterans of the Nazi concentration camp at Dachau during the World War II.

In any case, the hypothetical dramatic representations of Barbet are not entirely acceptable even for a few crucial aspects:

- A. The nailing of the feet with the right foot probably dislocated gave Jesus a support that allowed Him to breathe [21];
- B. In the case of Jesus, the ventilatory failure would be mainly due to the limited movement of the chest because of neurosymptoms like *causalgia* and leg cramping in accordance with experimental studies by Zugibe [22], and Ball [23], on volunteers, certainly not by numbness;
- C. The ability to drink and then to swallow, to give out two “loud cries” with the last short sentence “everything is finished” and the terminal “cry” in a context of full consciousness, are incompatible, a condition of severe ventilatory problems with asphyxia, that moreover does not lead to immediate death [24], and suggests that the deadly sequence has been produced by another decisive terminal event [25].

### Hypovolemic traumatic shock

According to Zugibe [26], the cause of Jesus’ death was “cardiac and respiratory arrest, due to hypovolemic and traumatic shock, due to crucifixion”.

Otherwise, according to the authors, Jesus did not die in a condition of severe shock which also entails loss of consciousness, because he had a clear mind, intact senses, breathing still valid and able to speak out. Indeed, in clinical practice no case of traumatic hypovolemic shock to holler and suddenly die [27], has been reported.

Most likely, Jesus was in a state of moderate shock characterized by loss of blood volume by 20% to 40%, <2000 ml; hypoperfusion of major organs (kidneys, lungs, intestine, liver ...)but not in heart or brain] and clinically by thirst, paler cold and sweating skin, oliguria and metabolic acidosis, shallow and frequent breathing, arterial hypotension, hypothermia (in the case of Jesus, probably accentuated because the average temperature in the first week of April in Jerusalem is between 8 and 14°C), agitation, generally intact senses.

We hypothesize that Jesus was a strong man with well-developed muscles, about 175 ± 2cm tall [28], with a supposed weight of 75 ± 7 kg. As the blood volume is approximately 7% of body weight, it is deduced that His blood volume was about 5,600 ml; the loss of blood volume decreased by about 40% (about 2,000 ml), the mostly from bleeding, and we imagine the loss so divided:

- 15% for the hemothorax (which we estimated to be

about 800);

- 18% (about 900 ml) for other bleeding: the hematohydrolysis, that is considered minimal [29]; the near death scourging (wounds and trauma-induced coagulopathy –see below– must have caused a large amount of bleeding and ecchymotic suffusions, and the body had to be somehow washed, to account for the preciseness of the wounds on the TS) [30,31]; the crown of thorns (bleeding not negligible but easily measurable); the crucifixion, which probably did not cause an important bleeding [32], because the nails sealed the wounds, the blood pressure was very low with arms in elevated position [33], the causalgia strongly restricting limb movements;
- The remaining 6% (about 300 ml) of the blood loss due to dehydration.

### Orthostatic syncope and cardiac arrest from suspension

“Orthostatic shock while suspended” is a state of shock due to a “orthostatic intolerance” to a passive suspension and immobility in a vertical position for a period of time, with inevitable presyncopal symptoms (such as dizziness, palpitations, sweating, nausea, blurred vision), blindness, syncope and rapid death because the blood becomes stagnant in the legs causing hypoperfusion to anoxia of vital organs, mainly of the brain. Other symptoms, in addition to fainting, are hypotension, bradycardia and apnea.

Factors that increase the risk of suspension trauma include: psychological state, the inability to move one’s legs to activate circulation, dehydration, hypothermia, fatigue, cardiovascular and respiratory diseases, traumatic injuries that cause pain or hypovolemia, block of the airway caused by head position, and any stress condition that induces the patient to lose consciousness, pre-existing state of shock [34,35].

All these risk factors were heavily present in the crucified Jesus.

Bishop and Church [36], have first hypothesized that a primary mechanism or contribution to death in crucifixion might be the orthostatic hypotension that causes hypovolemic shock alone or in addition to pre-crucifixion injuries.

Moreover, already Modder H. in 1949 [37], basing his opinion on specific tests, believed that the suspended position for the upper limbs at a given moment would have caused cardiovascular blocking causing cerebral anoxia and then death.

The phenomenon known in human physiology as term “orthostatic syndrome” is taken into account especially in aerospace medicine subjecting pilots to the test “lower body negative pressure” [(LBNP) [38], or in cardiology with the “head up tilt testing” or “passive orthostatic stimulation test”.

In LBNP tests the subject may intentionally increase tolerance contracting the muscles of the lower limbs. In

crucifixion, however, fatigue, trauma and causalgia reduce the ability of muscle contraction at an inadequate level to maintain appropriate blood pressure so syncope inevitably arises.

This explains the meaning of leg fracture in crucified subject, apparently a routine practice, which prevents the contraction of leg muscles and anticipates death.

For a man so tried, as Jesus, at the end of life, in a serious state of shock for the many traumas, bleeding and dehydration, with severe hypotension, metabolic and respiratory acidosis, but still conscious, hanging on the cross it, would have sufficed to stop breathing even for a few seconds, remaining motionless, without leverage on the feet and muscles contraction, to precipitate syncope and cardiac arrest so “he bowed his head and gave up his spirit” (Jn 19,30).

The hypothesis of syncope and cardiac arrest from orthostatic suspension are compatible only with the St. John version, in which Jesus “gave up over the spirit” after having exclaimed that “it was all over” and as if it were a decision of Jesus to avoid a futile suffering after everything had been done according to the plan of the Father.

How must we interpret the different reports between the three Synoptic Gospels and St. John?

According to Clement of Alexandria (150–215 AD), St. John must we wrote a spiritual and symbolic gospel that interprets the meaning of the Passion of Jesus to prove his divine origin; his Gospel completes the story of the other three evangelists who were been faithful chroniclers of what really happened. Therefore John’s Gospel is independent from the chronicle and assumes a symbolic and eschatological meaning.

### Pulmonary thromboembolism

It is thrombi (blood clots) or other materials (such as fat globules) that come off suddenly from thrombotic veins or traumatized bones, pass into the circulation and occlude (embolism) pulmonary arteries. It is frequently observed in polytraumatized, immobilized and dehydrated subjects.

In the Jesus’ case, in addition to the physiological release of tissue factors and increased procoagulant activity, there would probably have been additional hereditary genetic factors typical of the Jewish population resident Galilee, with a hypercoagulable state, such as congenital thrombophilia, particularly for Leiden factor V and prothrombin mutations [39].

The hematohydrolysis suffered by Jesus in the Olive Grove, can manifest itself in violent or emotional states in patients with haematological disorders [40,41].

While Brenner [39], affirms that this was the likely cause of Jesus’ death, it is necessary however to consider the following factors against this hypothesis:

- A state of dehydration and rhabdomyolysis (muscle disintegration with release of urinary myoglobin) cause

mainly pulmonary microemboli, not immediately life-threatening and a healthy young man of about 33 years of strong build would not succumb in such a short time[42];

- We do not know the Galilean genetic profile of two thousand years ago, different from the present due to the migration of Jews over the centuries [43]. Therefore, it is possible that the death, relatively fast after the crucifixion, is due to additional risk factors such as pulmonary thromboembolism.

### Trauma-induced coagulopathy

A recognized complication of traumatic shock is trauma-induced coagulopathy with increased bleeding. This acute coagulopathy occur in approximately 25% of trauma patients [44]; it begins early in the post-injury period and occurs when several factors are present simultaneously: coagulopathy, hypothermia and acidemia. Metabolic acidosis occurs secondary to tissue ischemia during shock and can increase clotting time and also decrease clot strength. This “lethal triad” can lead to progressive derangement of clotting mechanisms [45], with mortality rates nearing 60%. Indeed, Jesus had extensive tissue damage from multiple beatings plus widespread lacerations on the trunk and extremities from scourging with microembolism by release of lipid material and thromboplastic substances with consumption coagulopathy, blood hypocoagulability and also parenchymal hemorrhage [46]; certainly He could have been hypothermic from vasoconstriction in His extremities, blood loss, profuse sweating from anxiety, and exposure to cold environmental hanging naked on the cross.

In short, trauma-induced coagulopathy might have been a contributing factor, if not the primary factor [47], in the speedy death of Jesus.

### Multifactorial hypotheses

For the same exclusion criteria given above, it is also hard to believe that the cause of Jesus' death had the following multifactorial etiology:

- Hypovolemic shock and exhaustion asphyxia [48];
- Hypovolemic shock and exhaustion asphyxia, plus other contributing factors such as stress-induced arrhythmias, congestive heart failure, with pericardial and perhaps pleural effusion [49-51];
- Traumatic hypovolemic shock, secondary acute renal failure, rhabdomyolysis and metabolic acidosis by scourging [42, 52];
- Hemorrhagic-hypovolemic shock, progressive asphyxia and cardiac arrest, caused by vasovagal reflexes initiated by severe anoxaemia, severe pain, body blows and breaking of the large bones [53];
- Shock, dehydration, mechanical asphyxia by crucifixion, acute terminal cardiac ischemia [26].

## The Results of the Blunt Chest Injury

Jesus fell heavily to the ground under the weight of the cross, hitting His chest without any help of hands, while the cross or the patibulum with all its weight was put upon his back. In these conditions a severe injury to the neck, shoulder and chest is inevitable.

The authors are convinced that Jesus, with the fall and the violent chest trauma, had suffered not only a pulmonary contusion but also a cardiac contusion, which was not the immediate cause of death, but strongly influenced the course of his Passion.

### Pulmonary contusion

Pulmonary contusion consists of an extravasation of blood in the lung parenchyma not associated with a substantial destruction of the tissutal plot. It is considered the most frequent complication of thoracic trauma (26 %) [54].

In pulmonary contusions from falls, the histological examinations show that the bleeding originates from intraparenchymal laceration of vessels and the extravasation of blood fills the air spaces and adjacent bronchi. Generally, the lesions are localized in the lung parenchyma more directly below the site of the trauma, but the damages may be, also or predominantly, in the contralateral lung by a kickback effect.

In the pulmonary contusions, the radiological picture becomes positive immediately after the trauma and tends to regress rapidly after only 24-48 hours.

Symptoms are variable, from absent to a severe dyspnea, with cough, blood sputa and bronchorrhea. In the case of Jesus, we must assume that the lung damage was modest while the complications, namely the hemothorax and cardiac contusion, were more relevant.

### Hemothorax and the spurt of blood and water from the chest by lance

The hemothorax (blood in the pleural cavity) is a frequent manifestation of blunt trauma of the chest even without documented fractures. The hemothorax originating from pulmonary vasculature, expands, compresses the lung causing a vascular tamponade that can lead to the hemostasis [55] and therefore may be modest, without leading to a shift of the mediastinum.

The blood that fills the pleural space clots, but the coagula undergoes defibrination because of the deposit of fibrin on the pleura presumably following physical agitation produced by cardiac and respiratory movements [55,56]; in addition, the blood remains fluid by fibrin rupture through action of fibrinolysis normally produced by the mesothelial tissue [57]. The process of defibrination occurs rapidly, within a few hours [58] and so it is likely that the defibrination of blood started on the way to the Calvary.

In vivo, in the pleural cavity the defibrinated blood remains

homogeneous. The stratification with clots and compact red blood cells in sediment and with on upward serous component only happens after death not in vivo. Therefore, the leakage of blood and water from the side is the proof that Jesus really died on the cross.

The lance penetrated the right chest between the sixth intercostal space on the midclavicular line and the seventh intercostal space on the anterior axillary line, according to the authors and Ricci [59], not in the fifth space [60], (Figure 3).

In short, the centurion threw the lance in the VI intercostal space under serous layer and John saw the blood come out first, and then a clear watery liquid, i.e. serum, as it appears on the TS.

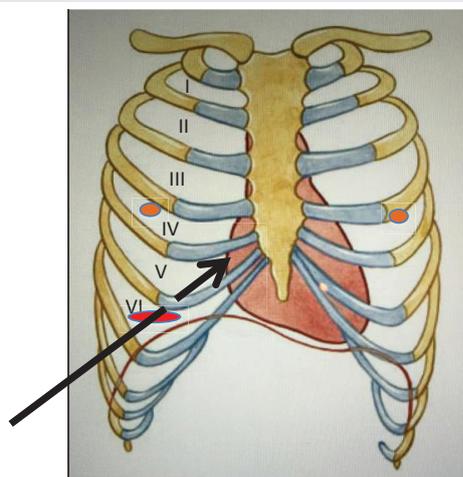
### Blunt cardiac trauma (or cardiac contusion)

In the majority of cases a cardiac contusion is a direct blow to the anterior chest wall (like steering-wheel injury) but the most serious myocardial damage has been produced by blows directed against the posterior chest wall [61], with compression of the heart between the sternum and the spine; greater cardiac damage seems to occur in patients without associated fracture of the ribs [62]. Exactly as in the case of Jesus detected for the TS Man carrying the cross.

Ball [63], too thinks that Jesus had suffered a chest trauma with the fall carrying the heavy beam on his shoulders, so he was not able to soften the blow, with his hands tied to it, causing him a cardiac contusion.

Unfortunately, the diagnosis of cardiac contusion can be often just assumed because of non-specific symptoms and the lack of an ideal test to detect myocardial contusion [64,65].

The clinical effects may be apparent immediately or may be delayed [66]. The spectrum of complication of myocardial contusion ranges from minor bruises of the myocardium to cardiac rupture. Severe myocardial contusion may induce a



**Figure 3:** Route hypothesis spear: piercing through the sixth intercostal space between anterior axillary and hemiclavicular lines. Path of the lance with the soldier on the ground and raised his arm. Thorax in inspiration. [From Sobotta. Atlas of Human Anatomy, modified].

decrease in cardiac function, but frank cardiogenic shock and cardiac rupture are rare complications [67–69].

Myocardial contusion that results from high energy impact is associated with myocardial lesions [70], such as intramyocardial hemorrhage, increased edema, polymorphonuclear infiltrates, muscular waxy necrosis so that the affected myocardial area appears pale pink or greyish similar to that of fish meat. The cutting surface appears dry, opaque, wax-like just as in the Psalm of David (Ps 22,15): “My heart is like wax, melting away within my bosom”.

### Myocardial infarction and heart rupture

The blunt cardiac trauma can be therefore considered prodromal to myocardial infarction (massive necrosis of the myocardium that occurs when the circulation in a region of the heart is obstructed).

The cardiac contusion alone does not explain the rapid death of Jesus. Heart rupture extremely close to the infarct is [71].

However, the hypoxia by ventilatory failure and causalgia, hemorrhagic-hypovolemic-politraumatic and suspension shock, the consequent metabolic acidosis, the hypothermia, conditions of extreme weakness, certainly aggravated the blunt cardiac injury with further insult to the coronary arteries and malacia, making it rapidly followed by myocardial infarction, and accelerate the cardiac rupture leading to the tamponade and the cardiac arrest.

When did the heart attack happen? We can only speculate. Maybe during the nailing and the severe stretching of the limbs to the dislocation, causing the first cry of pain (“My God, my God, why have you forsaken me?” Mt 27,46; Mk 15,34).

When did the heart break? Perhaps at the second cry followed quickly by death. This is a very suggestive hypothesis that the authors propose.

In fact, the heart rupture could be the source of the loud cry, which is not rare and documented [72]. For example, a young football player after a strong chest trauma from a blow of a leather ball remained at the post goal for 5–10 minutes accusing discomfort and shortness of breath then let out a cry and lost consciousness. At autopsy there were 350 ml of blood in the pericardial sac. There were no myocardial abnormalities or injuries to the chest wall [73].

This case seems to be paradigmatic for the interpretation of the reported facts in the Gospels and also the clinical picture such as myocardial infarction, heart rupture and tamponade do not conflict with the story of the three evangelists and with the biblical context (“Insult has broken my heart”) [Ps 69,21].

### Hemopericardium and the spurt of “blood and water” from the chest

As already stated, we can reasonably exclude that the post mortem spurt of blood and water from the lanced chest comes only from hemopericardium (collection of blood in the

pericardial sac) by heart rupture, or by a lance penetrating up to the right ventricle or right atrium.

One must consider:

- The tip of a Roman spear at the time of Jesus might have up to 28 cm long with a maximum blade width at the base of 5 cm, like the Italic lance (Chieti and Campli Museum). Therefore, it was able to penetrate up to the heart that is about 12 cm from the chest wall. The wound in the side is about 4, 5 cm wide and so compatible with it.
- The atrium can contain up to 250 ml of blood which is obviously not defibrinated, otherwise after death it tends to sediment and the red blood cells sedimentation rate in an infarcted subject, furthermore with polytrauma, is very high, so in one hour the above serious part can be greater than 60% of the total height of the blood column. In this condition, a possible stabbing in the lower part of the heart would make the blood come out before “water” [74]. The same goes for a possible stabbing of the right ventricle that has a stroke volume of about 70 ml.
- In acute diseases, cardiac tamponade due to hemopericardium is rapidly fatal for the collection of blood in the pericardial sac, around 200–300 ml [75], but also in smaller quantities (60 to 100 ml) [76]. This is due to the fact that the parietal pericardium is fibrous, tough and inelastic so that a relatively modest fluid increase rapidly accumulated compresses the heart and prevents diastolic filling, so the blood circulation and the heart rapidly stop.
- The complete defibrination of the plasma (for shaking the blood induced by rhythmic contraction and expansion activities of the heart) is quite rapid but the complete defibrination with fibrin deposition on the pericardial walls takes longer. However, the blood after death undergoes equally an erythrocyte sedimentation.

**Conclusion.** The hypothesis is that the bleeding at the chest came only from the atrium or right ventricle directly injured by the lance is not sustainable because they may contain only a small amount of blood. There would be an immediate passage of all the blood into the pleural space but this can accommodate, due to the lung collapse, quantities much greater than those contained in the pericardial sac without pouring blood out of the chest [77].

Therefore it is likely that the blood that came out of the pericardium wound was mixed with the blood contained in the pleura. This does not conflict with the theological thought of the Christian church.

Recently [46], it has been suggested that the cause of the cry and sudden death might have been a thoracic aorta rupture which most likely would have already been injured with a medial layer necrosis caused by aortic contusion during

the blunt chest trauma from falling to the ground, carrying the cross or patibulum, and in condition of hypoxemia by dyscrasic-hypovolemic-hemorrhagic-orthostatic shock.

This assumption is not credible because: a) the intrapericardial aorta rupture with cardiac tamponade is not compatible with the bleeding from the chest for the reasons given above; b) the ascending aorta rupture causes a hemothorax almost always to the left, rarely to the right or also to the right; c) in case of blunt chest trauma, the cardiac contusion is much more frequent than aortic contusion.

## Conclusion

From the discussion of the various hypotheses we deduce that the most likely immediate cause of Jesus' death was myocardial infarction complicated by heart rupture. This diagnosis, already supported by many scholars, such as Stroud [72], Cooper [78], Whitaker [79], Bergsma [80], Wedessow [81], Ball [24], is the only one that is compatible with a death in full lucidity and immediately after a loud cry, in accordance with the synoptic Gospels.

The other advanced conditions among the hypotheses of the causes of Jesus' death are to be considered as contributions which made the Passion of Jesus extreme and the death by crucifixion rapid, in a few hours.

The diagnosis of death can be expressed as follows:

- Myocardial infarction and heart rupture with hemopericardium in a subject crucified with the nailing of hands and feet;
- Severe emotional stress and depression;
- Severe hypovolemic-traumatic shock, resulting in multiple traumas, dehydration by sweating and without drinking; bleeding from hematothrosis, scourging, crown of thorns, nailing, hemothorax;
- Acute respiratory failure at a first stage by crucifixion and causalgia;
- Blunt trauma following the fall with paralysis of the entire right brachial plexus, right shoulder dislocation, pulmonary contusion with hemothorax, cardiac contusion;
- Probable left ulnar proximal paralysis and right foot dislocation from stretching during crucifixion.

Only a man sustained by a faith in his mission, conscious of his martyrdom, though young and strong, could bear such a massacre with a deep and absolute peace of mind!

Our clinical and experimental research, in perfect agreement with the biblical account, the tradition and Christian Doctrine, has contributed to clarifying the Passion of the Man of the TS that is most likely Jesus of Nazareth.

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