

HISTORICAL NOTES**THE HISTORY OF THE ABDOMINAL COMPARTMENT SYNDROME****D. N. Paduraru^{1,2}, Georgiana Radu², O. Andronic², Alexandra Bolocan¹, D. Ion^{1,2}**¹3rd Department of General Surgery, The University Emergency Hospital Bucharest, Romania²The University of Medicine and Pharmacy "Carol Davila", Bucharest, Romania

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Abstract

Abdominal compartment syndrome (ACS) was not, until now, a very popular research subject. Even though it can be encountered not only in trauma surgery, but also within the progress of other diseases, the resources for its research were not widely available until the late 20th century. We aim to present a small history of intraabdominal hypertension (IAH) and its worse successor- the abdominal compartment syndrome (ACS). The interest for these subjects had been present even since 1600 b.c., but only now we have really started understanding the phenomenon and its implications. The journey of their research throughout history has been interesting and, in the same time, a challenge for doctors in every age of time, as many of them tried to discover their pathophysiology, mechanisms and ways of prevention. Every step forward mattered and has brought us to the knowledge we have and use today in our mission to save lives.

Keywords: *intraabdominal hypertension, abdominal compartment syndrome***Introduction**

From the onset of modern history of caring for patients with IAH and ACS until now, many researchers have tried to answer the question: "What really is ACS?" and at the same time to assess health professionals' level of knowledge on what recognition and management of IAH / ACS means [1-4].

Recognition and complete understanding of what IAH/ACS actually are represents an optimal tool for a most effective orientation in inpatient care in general surgery clinics, because the terms "IAH/ACS" describe a variety of pathophysiological theories.

This historical study aims to evaluate references in this field starting with the first few assumptions about the management of patients with HIA until now, hoping that throughout this

research we can bring great benefits to the medical community.

IAH and ACS through history

If we think that the first etiological factor of ACS was supposedly traumatic, we all know that from the beginning of its existence, the man has suffered traumatic injuries by falling, fire, drowning, interpersonal conflicts and, although the mechanism of the lesion and its frequency have changed over time, today they remain an important cause of morbidity and mortality in modern society, not infrequently happening because of the association with IAH.

Thus, the first information suggesting ways forward in caring for patients who after abdominal trauma showed "increased abdominal volume", was offered by the Iliad and the

Odyssey, Homer's epic poems. They were written around 700 b.c. and describe the events that had happened 5-6 centuries before. A real traumatic etiology mortality statistics is described there, but what we want to emphasize is the presence of several issues of interest to current therapeutic approach in patients with HIA.

One aspect that deserves to be significantly emphasized because of the importance it has in our research refers to patients with abdominal trauma produced by spear. They were left with their abdomen open. It was believed that associated mortality of such trauma was about 80% [6] and that it was necessary to follow the case for a few days after which, depending on the evolution, to decide the so-called "therapeutic attitude." Thus, given that at the date we speak of, there were guidelines consistent on the attitude required before a patient develops HIA, it is surprising to us that the first clinical information that makes clear reference to HIA or ACS was described only in 1800. The historical research of this medical realm becomes more fascinating, as the interest in this pathology has further increased only in recent decades.

MESOPOTAMIA

Mesopotamia, the land between the Tigris and Euphrates, was the place where most civilizations had appeared and decayed: Sumerian, Chaldean, Assyrian, Babylonian.

Documents from those times make us conclude that the doctors of Mesopotamia were familiarized with a large specter of diseases, some of them concise, with a clear symptomatology (like dysentery, pneumonia, epilepsy) and others of which only few ideas can be contoured, including IAH which was present as a general syndrome that debuted with anuria [6].

INDIA

During the times that we are speaking about, surgery was in plain evolution. Sushruta-Samhita is the oldest surgical treatise [8]. In between its pages clear aspects regarding surgical attitude (limb amputations, hemostasis though cautery, fracture immobilization, tumor

resection, gynecological interventions) can be found [9], description of special surgical beds, beds for patients with fractures, more than 130 surgical instruments and also some surgical attitudes only supposed to be correct, some of which being of real interest for what was about to become the management of the patient with a syndrome of IAH. The idea of the enlarged abdomen's decompensation or the positioning of a patient with an enlarged abdomen on a special bed are just a few of the themes debated at those times, together with real efforts to obtain accurate anesthesia and aseptic [8].

EGYPT

Smith, Ebers, Hearst and Brugsch papyruses are source of medical description for those times [9,10]. Smith papyrus (1600 b.c.) can be considered a true war surgery manual, where the title of the presentation, examination, diagnosis, lesion classification and treatment were described [8,10]. Still, pictures of surgical interventions were discovered inside tombs, being older than the papyruses and dating around 2500 b.c. [9].

Physical evidences, as well as written ones, show that surgical interventions were rare and simple, being limited to fracture treatment and incisions around different body areas, most of them situated at the abdominal level.

It is clear, from their description, that a traumatic etiology was at the base of these procedures. Because of this, multiple abdominal surgical interventions were described (abdominal incisions) in the case of patients with an abdominal trauma complicated with an enlarged abdomen and no diuresis [10].

We draw attention over this aspect because, even though the abdominal surgical interventions cannot be quantified and compared to actual standards, by a comparative analysis between surgical practices then and now for diverse pathologies we can contour the idea of a remarkable therapeutic attitude that we also use today: "abdominal incisions for those with an enlarged abdomen and no diuresis".

THE ROMAN EMPIRE

Using Greeks', Etruscans', Egyptians', Persians' and other conquered people's medical

knowledge, the romans had created one of the most complex medical systems. After the destruction of Corint (146 b.c.), Greek medicine moved to Rome. Initially, romans were skeptic about working as a doctor, not because they were condemning medicine as a science, but because they considered taking taxes for treatment as an unethical practice.

Even though, as we previously mentioned, roman medicine was totally in Greek hands, the best description was made by Aurelius Cornelius Celsus in *De Re Medicina*. Celsus was not a physician, but a noble who wrote treatises about agriculture and medicine. *De Re Medicina* contains volumes. First four of them are about diseases treated though diet and the last ones are about those that could have been treated by treatments and surgery, the last one being addressed in the 7th volume. The first notes about vascular ligatures and intestinal occlusions were made here.

During The Roman Empire surgery got to a grade of perfection unattained before Ambroise Paré. More than 200 surgical instruments used in complex surgical interventions for hernias, cataract, caesarian sections, plastic surgery were described at Pompei. Moreover, it is specified that there were patients with an enlarged abdomen whose evolution was frequently critical, encumbered by the presence of a multiple organ failure or even exitus.

MIDDLE AGES

Ideas about The Universe, human being, his relation with the Creator and medicine suffered profound changes during Middle Ages (500-1500). The almighty Roman Empire entered a period of decline, when in 330 the emperor Constantinus set the capital at Byzantium (Constantinople). To the end of the 4th century the separation between the East and West had become permanent. The East became The Byzantine Empire and the West entered a dark age [7]. Along with the growing influence of the Catholic Church and the need to suppress heresy and science, medical discoveries were stagnated along Western Europe for hundreds of years. After the year 500, in the town Gundishapur (Iran of today), many sciences had developed, including education and medicine. The Academy in Gundishapur was the first

university hospital [11]. This historical landmark represents, in our opinion, a very important step for what general medical evolution means and for the progress of research in university hospitals.

A very important personality of those times was Avicenna (980 – 1036), name “The prince of doctors”, who was a doctor at the hospital in Bagdad and wrote more than 100 papers. Unfortunately only few of them were preserved. His treatise, *Canon*, tried to systemize medical knowledge of those times and to bring them in harmony with those of Galen and Aristotel [9]. We would like to draw the attention towards this particular paper because it was utilized in universities of Leuven and Montpellier until around the year 1650 [11]. Unfortunately this treatise had a negative effect because it sustained the idea that “rationalization is preferable to investigation”. The progress of surgery was also stopped because of the idea that it is an inferior segment of medicine [9].

This represents one of the phases that also held back discoveries in the correct attitude when faced with patients having an IAH/ACS. We emphasize this idea because, by quantifying actual causes that lead to the appearance of IAH, it can be concluded that the frequency of patients who developed IAH in those times was very high. In exchange to this inconvenient, Albucasis published a medico-surgical treatise called “The Collection”. We remark this scientific appearance because, besides important data about amputations, wound treatment, sprains, pelvis fractures and paralysis as a consequence of spinal cord fractures, it contains, for the first time in history, information about what will become the management of patients with IAH syndrome, by adding data about the pathophysiology of IAH through the hypothesis that when a changes happens within the abdomen of a patient, he presents an enlarged abdomen pain and dyspnea[9].

RENAISSANCE AND THE SCIENTIFIC REVOLUTION (1450 – 1700)

In 1452, Constantinople was conquered by the Ottoman Empire and many byzantine intellectuals fled to Italy. Thus, many Greek and Roman texts were rediscovered, this way

leading to the appearance of the Renaissance [11].

It is considered that the Scientific Revolution had begun in 1534, when Nicolaus Copernicus published „De revolutionibus orbitum coelestium” and Andreas Vesalius published „De humani corporis fabrica” [12,13].

Andreas Vesalius (1524 – 1564), the creator of modern anatomy, was born in Brussels [11]. He studied medicine at the University of Paris where he learned Galen’s anatomy with the famous professor Jacob Sylvius [12, 13]. He left Paris and graduated in 1537 the Faculty of Padua. The next day he was named professor [14]. He did lots of dissections, observing that Galen’s notions came from animal dissections and do not correspond with the human anatomy. His treatise “De humani corporis fabrica” impresses through information accuracy and beauty of his drawings [12,13]. This paper brought important data about anatomy and physiology. Thus, on a large scale, we consider it a founding paper for medicine by bringing important benefits for what the actual management of the IAH means.

MODERN HISTORY – TAKING CARE OF THE PATIENT WITH IAH

Because all our information from 1860-2014, when medicine becomes a science, are clearer and present in multiple specialty papers, we would like that, in continuation, the presentation of all historical marks to be punctual:

- Schein [15] signaled that the effects of an increase in IAP have been known since 1863 when Marey observed the effects of a breathing “stimulation”, expressed actually as an increase in respiratory frequency, appeared proportionally with the abdominal volume.
- Braune is the one who, in 1865, did the first measurement of the IAP through the rectum [16].
- Oderbrecht is the one who, in 1875, did the first measurement of the IAP through the gallbladder [17].
- Heinricius, by some animal experiments done in 1890, has demonstrated that through an increase in IAP from 27 to 46 mmHg, the consequence is the subject’s death. He has also intuited some causes for this as: breathing

deterioration, a decrease in cardiac diastolic distension and hypotension.

- Wendt, in the year 1876, did the first few observations regarding renal impairment determined by an increase in IAP [19,20].

• Esmerson, in 1911, has conducted numerous experiments on animals that got him to some conclusions regarding consequences of an increase in IAP, like:

- A reduction in diaphragm movement represents the main factor for the decrease in respiratory volume
- An increase in IAP also increases peripheral vascular resistance
- Excessive IAP can cause death through cardiac failure before the development of asphyxia. He has also demonstrated that pressures bigger than 45 mmH₂O will kill a small animal

Esmerson utilized gas or liquid in order to produce an abdominal distension in his experiments, thus concluding that besides a compromise in cardiac function, a increase in the resistance in the splanchnic territory will also take place. Same author formulates hypotheses like the ascites fluid’s removal conducting to a decrease in cardiac workload, which he then establishes as therapeutic attitude directions [20].

We consider this last physiological observation as one of the main therapeutic principles that is valid even today in many cases that involve ACS. It also grounds the question “when and until when are we capable of treating a patient with ACS through NSM (non-surgical management)?”

- Bellis and Wangestten, in the year 1939, described changes determined by IAH in the abdominal and peripheral venous circulation [21].
- Bradley, in 1947, evidenced, deepened and formulated two of the physiopathological effects of the IAH in the renal level [22]:
 - A decrease in glomerular filtration rate
 - A decrease in renal plasmatic flux in the case of an increase in IAP
- Gross introduced the technique for the gradual repair of the abdominal wall in the surgical cure of ompahlocel [23].
- Sönderberg and Westin have demonstrated a correlation between IAP measured during

laparoscopy and the one measured through the gallbladder [15].

- Most of the authors consider that the decisive moment in the « reinventing » of consequences of IAH and especially of ACS is Kron and al.' article from 1984. The authors bring concrete data regarding the fact that opening the abdomen in 7 out of 11 patients with postoperative oligoanuria and IAP > 30 mmHg has saved their lives [24]. Even though most papers associate Kron's name with the « ACS » term, it is incorrect as he did not use it.

- Fietsam and al. were the innovators of the « ACS » term [25]. They used it for the first time in 1989, for the description of all physiopathological alterations that can appear in the case of IAH determined by an aortic aneurism. They reported 4 cases of IAH that did not resolve post-surgery in patients with a ruptured aortic aneurism. Common clinical manifestations in these patients were:

- An increase in the ventilator pressures
- An increase in central venous pressure
- A decrease in diuresis

Authors accentuate some notions that we consider clinically relevant today, especially for general surgery:

- ACS can be caused by interstitial and retroperitoneal edema
- All 4 patients received more than 25L of liquid for fluid resuscitation
- The abdominal decompression incision was associated with a significant evolution improvement

- The year 1989 is very important to what the actual management of patients with IAH means because of the appearance of laparoscopy. This has permitted, through the measurement of complex effects that pneumoperitoneum has, a more exact definition of problems that an increase in IAP brings. In time, the appearance of the „damage-control laparotomy” concept has consecrated ACS and the necessity of its prevention.

We would like to draw attention upon the fact that, even though they were firstly described more than a century ago, IAH and ACS were recently rediscovered, in many situations as a perimorbid syndrome, in the context of severe trauma or a severe abdominal disease.

The rediscovery of IAH/ACS in the 1980s and the beginning of the 1990s has conducted to a rebirth in the research of this subject. The literature from these times describes very well the physiopathology of IAH/ACS along with options for the clinical diagnosis and therapeutic management. Most of the studies draw attention towards ACS of traumatic etiology. Also, the literature tends to be mainly composed of limited prospective clinical research [5].

Along with the newly discovered interest for this subject it became obvious that ACS does not appear only in patients with critical politrauma, but also in a wide specter of afflictions.

The moment with the biggest scientific impact was in December 2004 when clinicians and researchers all across the world gathered together at Noosa, Australia in order to form the World Society on Abdominal Compartment Syndrome (WSACS). This inaugural congress gathered numerous studies and scientific papers. This way some steps in the establishment of clear consensus definitions of IAH/ACS have been outlined [26]. These definitions permitted a substantial clarification of diagnosis criteria and helped establishing research accuracy regarding this subject.

The name of the Society was recently changed to WSACS – the Abdominal Compartment Society to largely include all pathologies associated with IAH and ACS. 2013 is the year the updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome was last published. It remains to be upgraded along with science progress and the accumulation of new information about the subject [27].

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