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SHORT COMMUNICATION

Primitive robotic procedures: Automotions for medical liquids in 12th century Asia minor

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Summary ***In recent years, day by day, robotic surgery applications have increase their role in our medical life. In this article, we reported the discovery of the first primitive robotic applications as automatic machines for the sensitive calculation of liquids such as blood in the literature. Al-Jazari who wrote the book "El-câmi 'Beyne'l - 'ilm ve'l - 'amel en-nâfi 'fi es-sınaâ 'ti'l - hiyel", lived in Anatolian territory between 1136 and 1206. In this book that was written in the twelfth century, Al-Jazari described nearly fifty graphics of robotic machines and six of them that were designed for medical purposes. We found that some of the robots mentioned in this book are related to medical applications. This book reviews approximately 50 devices, including water clocks, candle clocks, ewers, various automata used for amusement in drink assemblies, automata used for ablution, blood collection tanks, fountains, music devices, devices for water lifting, locks, a protractor, a boat-shaped water clock, and the gate of Diyarbakir City in south-east of Turkey, actually in northern Mesopotamia. We found that automata used for ablution and blood collection tanks were related with medical applications; therefore, we will describe these robots.***

KEY WORDS: *Robots; History of Urology; Robotic surgery.*

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INTRODUCTION

The word *robot* was first used by Czech playwriter *Čapek*, in his play '*Rossum's Universal Robots*' (1920), wherein he described a population dependent on mechanical workers, which he called robots (1). These robots were capable of performing every kind of intellectual and physical function (2). By the 1980s, surgical robots were in use for neurosurgery and orthopedic surgery (3).
Recently, robot-assisted surgeries have been involved in surgical applications and are becoming more widespread as well as they improve with each passing day.
The "*Da Vinci Robotic Surgical Platform*", is the most commonly mentioned such device nowadays. The platform was named after *Leonardo da Vinci* (1452-1519), who is generally recognized in the literature as the first to design a robot. However, based on in-depth research into the history of robots, it is highly possible to see that the first mechanism of a robot and the relationship between robots and medical sciences occurred in Anatolian territory in the twelfth century.
Al-Jazari (1136-1206), who is known to have had a distinctive knowledge of mechanics, engineering, and automation, was a Turkish scholar known to have been "*the ancestor of automation and robots*" and lived in the twelfth century (4). *Al-Jazari* was born in Cizre, Mardin Province, and lived in the city of Amid, now known as Diyarbakir, in the period of the Artuqids. As a scientist, he served for 32 years as chief engineer in Artuqid Palace. He wrote his book, *'El-câmi 'Beyne'l-'ilm ve'l-'amel en-nâfi 'fi es-sınaâ 'ti'l-hiyel* (*The Book of Knowledge of Ingenious Mechanical Devices*)' in the name of the throne of the Artuqids. In this article, we discuss *Al-Jazari* and explain that he has recently been credited with the design of nearly fifty robots in the twelfth century; six of these were designed for medical purposes.

MATERIALS METHODS

This book by *Al-Jazari* was described as a work forming a keystone of world technological history and a work ahead of its time (5). However, the first explanatory English translation of this book was by *Donald R. Hill* in 1974 (6). Then, in 2002, *Sevim Tekeli* and her colleagues translated and edited it into Turkish (5).
The mechanisms that gave this reputation to *Al-Jazari* could be described as follows: robot serving drink to sultan, robot drinking on feet, robot drinking leftovers of sultan's chalice, clocks that ring alarms for the hours with a series of events occurring automatically and combination lock mechanisms (with 3.55 x 1015 probability of unlock) that are similar/better to today's combina-

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tion locks (5). In another work, *Al-Jazari* drew peacocks from whose mouths water flowed and robot men of machinery that poured abluting water into the hands of his beloved sultan who wished to avoid employing slaves in the palace.

Results

We especially evaluated robot designed as ewers, blood collection tanks, and washbowls for ablution which we think were pioneering automatic mechanisms for the health sector.

Ewers, washbowls for ablution, and automata designed for hand washing sink with peacock used for ablution (Figure 1a)

The device consists of a sink placed on the ground, four columns rising above the sink, and, on these columns, a castle with two gates carrying the peacock.

The neck of the bird is laid like a spring and its beak is toward the sink. Its tail is vertical. Water flows through the beak of the bird. At that moment, one of the gates opens and a robot child appears holding a soap pot in his hand. When the water flow is stopped, another gate opens, and from there another robot child holding a towel emerges.

Automat designed for hand washing (Figure 1b-c)

This mechanism consists of a platform with a child holding an ewer in the right hand and a comb and towel in the left hand. In addition to the platform are a tank with a peacock adjacent to a platform, its beak pointing toward the floor, and a dome, which is placed on four columns on top of the platform and is capped with a bird.

Water flows through the ewer and the bird sings as long as it flows. Flowing water is collected in the tank and the bird drinks it. When the water runs out, the child passes the towel and the comb using his left hand.

Blood collection tanks

Among *Al-Jazari*'s works are blood collection tanks that measure the blood collected from a patient. No record has been found related to the blood collection tanks designed on the base of principles of equilibrium before *Al-Jazari* (7). In this automaton, floats rise with the help of a liquid that is collected in a pot and causes a counterweight to be lowered.

The device described here and illustrated with a picture serves for the measurement of blood collected by cupping (8).

Tank with a monk indicating the amount of blood flow (Figure 2a-b)

The machinery is shaped like a sink and is placed on the ground. A monk stands on the platform in the middle of the tank. There is a "C" hole through which blood flows to the collector in the bottom of the tank. The blood drained into the tank flows to the collector from the hole. The collector has a "D" float and there is a rope "E" bound to the top of it. The rope coils up the "F," "G," and "H" reels inside the platform that carries the monk and the "J" weight is bound to its end. The shaft of the "G" reel, "K," comes out of the platform and is fixed to the feet of the monk.

The monk has a rod and it reaches the edge of the tank, which is numbered from 1 to 120. The device is located in front of the individual from whom the blood will be collected. When the blood

Figure 1.
(A) Sink with peacock used for ablution.
(B-C) Automat designed for hand washing.

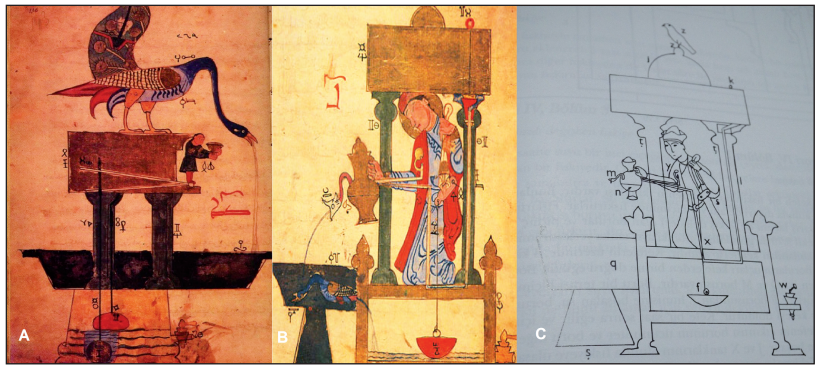
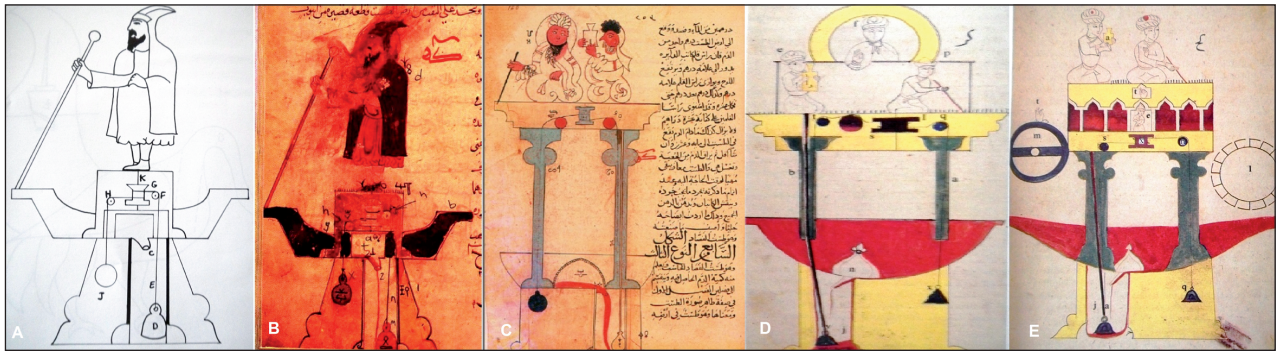


Figure 2.
(A-B) Tank with a Monk indicating the amount of blood flow. (C) Blood collection tank with two clerks.
(D) Calculator tank by which collected blood amount can be measured. (E) Blood collection tank with a castle.



has been drained into the tank, the float rises and the "G" reel spins. In accordance with the spinning of the reel, the monk and its rod spin in a way that shows the amount of blood taken. The rod in the hand of the monk reaches the first sign once 1 dirham (dirham = 3.207 gr) of blood has been collected in the tank (5).

Blood collection tank with two clerks (Figure 2c)
This mechanism consists of a sink placed on the ground. Four columns rise from the tank's floor, and a platform on the column supports two seated clerks. In the hand of one of the clerks, there is a pen, and the tip of the pen is on the arc of a circle numbered to 120.
The other clerk holds a segmented plate in one hand, and in the other a pen is positioned close to the surface of this plate.
The clerk holding the pen spins accordingly as the blood drains off to the tank and the plate in the hand of the other clerk rises. The blood amount collected is indicated by the segments indicated by the pens of both of the clerks (5).

Calculator tank in which the amount of collected blood can be measured (Figure 2d)
The mechanism consists of a tank placed on the ground and having four columns located on a floor. There is a platform on the columns on which two clerks are seated. One of them holds a pen, while the other has a plate.
There is a castle between the two clerks in which the chest, head, and two hands of a third man can be seen. As long as the blood is flowing into the tank, the pen of the clerk continuously shows the amount, while the plate of the other clerk shows the same amount.
When the blood amount is 10 dirhams, the man in the castle shows this with his hands and shows 20 when the amount reaches 20 dirhams (5).

Blood collection tank with a castle (Figure 2e)
The mechanism consists of a tank with six columns on the floor, at the top of which is positioned a castle with twelve gates and two wings at each gate. Two clerks are seated atop the castle. One of them holds a pen and the other has a plate. The appearance of the mechanism is similar to that of the other blood collection tanks. The movements of the clerk's plate, of the clerk holding the pen, and the hand seen at the "P" window are the same as those of the figures in the previous tanks. However, ten figures of children emerge from the gates to show each amount of 10 dirhams of blood and show 10, 20, 30 . . . and 120 dirhams with their hands that are positioned on this device (5).

Discussion

Al-Jazari described many machine parts that are included in the European engineering terminology of the current time, plus he mentioned these long before *Leonardo Da Vinci,* who first referred to the cone valve in the 1500s (4). In the machines he designed, *Al-Jazari* was the first to use the systems that are reminiscent of "*the crankshaft*" and "*camshaft*" that are now used in all motor vehicles (9-11).
These automatic ablution machines and automata designed for hand washing can be accepted as the first design draft of the hand-washing sinks and automatic towel-holding apparatuses used especially in surgery rooms today and it is astonishing that this level could be reached in the circumstances of the twelfth century.
Al-Jazari invented a blood-letting measuring device that contained a maximal amount of 120 dirhams (120 dirhams = 120 x 3.207 = 380 g), which, interestingly, corresponds to one unit of blood.
Probably the maximal amount of blood to be transfused at one time had been kept at that level, which is nowadays used as a cut-off value.
Al-Jazari started to fabricate a blood-letting measuring device with a simple design and then invented more sophisticated models. In the first of his blood collection devices, the amount of blood drawn was indicated with only one robot (Figures 2A-B), while he mounted four indicators in his latest robots (Figure 2E). To us, this contrivance suggests transmission from a one-armed robotic telescoping grasper system to four-armed robotic surgical systems.
Based on literature reviews, robotic surgery was firstly employed in 1983 during an orthopedic procedure; however, *Al-Jazari* is the scientist who designed the first robot, which he used in medical procedures in the twelfth century.
In fact, his peculiar automation of a blood-letting measuring device displayed the amount of the blood drawn at a given moment during a phlebotomy procedure (2). Even though some devices were fabricated that resembled the automata made by *Al-Jazari* in the twelfth century, the crank gears designed and used by *Al-Jazari* that were depicted in his works were quite distinct from any others. It is known that the crank system was firstly used by Leonardo da Vinci in the twelfth century (10).
Thus, the name of the robotic system used in urologic surgery is dedicated to him (da Vinci robots). But in fact, *Al-Jazari* used this system 300 years before da Vinci and depicted its three-dimensional design, which we still admire today.
Even in the article in which the historical background of the "*da Vinci*" robot was told, *Al-Jazari* was credited as the first scientist to have invented the first programmable humanoid robot (2).
Inventions of *Al-Jazari* are still in vogue in modern engineering (12), and with his everlasting designs of automata, he is regarded as the "*father of robots*" (13-14). Not only did he invent automata that were not surpassed for centuries, he also described their construction process step by step. Robots fabricated based on his instructions in his works, are still functioning perfectly well.
In conclusion, we think that robots were firstly described, and even used in medical procedures, by the famous scientist *Al-Jazari* even three hundered years before *Leonardo da Vinci*, thus recently, popularized as "*da Vinci*" *robotic surgical systems*. Even though he depicted his robotic systems in his books, *Al-Jazari*'s robotic contrivances could not pass his name on to future generations.
This heritage should be transferred to future generations, and his life and his inventions should be better recognized.

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