Leonardo da Vinci and the Mitral valve

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...With what words will you describe this heart so as not to fill a book? The longer you write on the details the more you will confuse the mind of the auditor. You will always be in need of commentators or be required to return to experience, which in your case is very brief, and gives knowledge of but few things concerning the whole subject of which you desire an entire knowledge.”
“Anyone who looks very attentively at the hollow of Mona Lisa’s throat can see her beating pulse (battere I polsi).”

• Vasari. The lives of the most excellent architects, painters and sculptors in l’opera 9 volumes Ed. Gaetano Milanesi. Florence 1906, 4:40
Of the thousands of art works by more than 160 artists reviewed by Vasari in his 2nd edition of “The Lives” only the Mona Lisa asserts a living presence by reason of a perceptible beating pulse
Leonardo on the pulse

• “..and the same thing happens in the bodies of animals by means of the beating of the heart which generates a wave of blood through all the vessels which continually dilate and contract. And dilatation occurs on the reception of the superabundant blood and diminution occurs on the diminution of the received blood. This, the beating of the pulse teaches us when we touch the aforesaid vessels with our fingers in any apart of the living body.”

• W 19045 recto
The Pulse

• Elsewhere he states:

- The movement of liquid from one direction proceeds in the original direction as long as the force remains in it which was given to it by its first mover.... The heart in this case.

- W 19045 recto
Life of Leonardo da Vinci

- April 15th. 1452 : Born in the Tuscan hill town of Vinci 3.0am
- Illegitimate son of local notary Ser Piero & a young girl Caterina of the local village of Anchiano. Baptised following day (Sunday) in the church of Santa Croce in the presence of 10 witnesses.
1464–1470: Ser Piero showed some of Leonardo’s drawings to Verrochio, following which Leonardo was apprenticed to the famous sculptor and artist.

Fellow SpR’s were Perugino and Botticelli

Verrochio: an anatomical artist
1472 enrolled into the Compagnia di San Luca, guild of Florentine artists.
Lived with Verrochio in 1476.
..when Verrochio saw it he vowed never to pick up a paint brush again!.....

“He is a poor disciple who does not excel his Master”
Anatomical studies can be divided into 3 main periods

Period 1 : 1487 - 95 :
Very reliant upon pre-conceived ideas from Galen especially
Anatomical studies can be divided into 3 main periods

Period 2: 1504 – 1509 (aged 52 – 57).
This period is more observational.
Dissected the centenarian in Florence, although still with significant Galenic influence
Anatomical studies can be divided into 3 main periods

Period 3: 1510 – 1519

Leaves Milan. Much more Intuitive & observational. Studies abdominal organs, digestive tract, blood and circulation, heart and hydrodynamics
How did he gain this knowledge?

“And thou, man, who, by my labors dost gaze upon the marvelous works of nature, shouldst thou judge mutilation to be an impious thing, reflect then that it is infinitely greater impiety to take the life of a man............” 19001r/FA2r/c.1510-13
“in order to obtain an exact and complete knowledge, I have dissected more than ten human bodies, destroying all the various members, and removing even the smallest particles of the flesh which surrounded these veins without causing any effusion of blood other than the imperceptible bleeding of the capillary veins. And, as one single body did not suffice for a long time, it was necessary to proceed by stages with so many bodies as would render my knowledge complete; and this I repeated twice over in order to discover the differences”
... “...and though you have a love for such things you will perhaps be impeded by your stomach, & if this doesn’t impede you, you will perhaps be impeded by the fear of living through the night hours in the company of quartered and flayed corpses fearful to behold. & if this does not impede you, perhaps the lack of draughtsmanship which appertains to such representation; & even if you have the skill in drawing, it may not be accompanied by a knowledge of perspective; & if it were so accompanied, you may lack the methods of geometrical demonstration and methods of calculating the forces and strength of muscles; or perhaps you will lack patience so that you will not be diligent. Whether all these things were found in me or not, the hundred and 20 books composed by me will give the verdict, yes or no. In these I have been impeded neither by avarice or negligence, but only by time. Farewell”
“...and this old man, a few hours before his death, told me that he had passed one hundred years, and that he was conscious of no failure of body, except feebleness. And thus sitting upon a bed in the hospital of Santa Maria Nuova at Florence, without any untoward movement or sign, he passed from this life.”
“...and I made an anatomy to see the cause of a death so sweet, which I found to proceed from debility through lack of blood of the artery which nourishes the heart and the lower members. I found this artery very desiccated, shrunken and withered.”

“Coronary Atherosclerosis”
“...Vessels which (in the elderly) through the thickening of their tunics, restrict the transit of the blood and, owing to this lack of nourishment, the aged failing little by little, destroy their life with a slow death without any fever. ...And this occurs through lack of exercise since the blood is not warmed.”

He asks why the veins in the aged acquire great length and tortuosity and thicken. Why this is more marked in the proximal vessels?
Methodology

- Asking the right questions
- Design the experiment
- Mimic reality (wax injections)
- Using lateral knowledge (hydrology)
- Choose the correct experimental model
  - (Ox Heart)
Suggested glass model to replicate the normal aortic root

“A plaster mould to be blown with thin glass inside and then break it from head to foot at an. But first pour wax into this valve of a bull’s heart so that you may see the true shape of this valve”
Leonardo’s drawings in medical contexts.
Heart... This moves of itself and does not stop unless forever... Marvellous instrument, invented by the supreme Master

• “The Heart in itself is not the beginning of life, but it is a vessel made of muscle, vivified and nourished by the artery and vein, as are the other muscles”.
• Developed a method of dissection of the heart still relevant today.
Atrial contraction preceding ventricular contraction

Manuscript G

Paris
The argument for a 4 chambered heart

• “The upper ventricles (atria) are separated by certain little doors (gateways), from the lower ventricles.”

• “Furthermore, if it (atrium & ventricle) is one and the same, there is no need for the membranous doors, (valves) that separate one from the other.”
Summer 1504 sailing off the island of Elba he noted: 
“Give the names to the chordae, which open and shut these two sails, that is, call the main one the bowline, topmast and the like.”
Human heart
OX
More subtle features of mitral valve anatomy:

- Chordal insertion
- Doming of the valve
- Scalloped post leaflet
- Depth of pericommissural leaflet
- Relationship to the aortic valve
- etc........
• To make a point
  Drawing>B&W>
  Colour photo.
“Here are the membranes which close the gates of the ventricles. In order that the resutting of this ventricle by the percussion of the wave of impetus on these membraneous valves should not force them from behind (leaflet prolapse), necessity provides them with powerful chordae which sustain the percussion of such impetus. . . . . and these valves just like the left sided ones shut with complete and perfect closure”
Coaptation line: “the lips of the junctions of the membranes are bent down in this manner” W 19080 recto
On the closing and opening of the greater gates of the heart.

• “The cusps of the greater gates of the heart are closed by the percussion of the blood escaping from the lower ventricle......they are reopened by the reflux of the blood pushed from the upper ventricles into the lower. And the vacuum that would be created by the opening of the lower ventricles ...is the cause of pulling them back into themselves the blood of the upper ventricles (atria), as they are emptied.” W 19063 recto
On the chordae tendinae....

• The chords which arise from the muscles of the heart and are converted into the membranes which become the cusps of the great valves of the heart are those which hold the cusps of the valve so that they do not pass out of the opening, but with their extension they increase and are applied to each other making perfect closure.

• In front the gates are found to be membranous and they are held from behind, that is, protected from within by threads which prevent their reversal”

- W19078 verso
Leaflet closure

• “On the valves of the heart. On the shutting of the heart the valve cusps of the heart always give passage first to a quantity of blood before they shut from within outwards”
- Miral valve is Quadri-leaflet!
He perceived the leaflets to consist of two layers, that formed by the condensations of the chordae tendinae on the underside and the smoother atrial layer. W19078 v & W 19074 r
incisions

Open & closed aortic valve

Coronary circulation

Coronary sinus: artery always beneath vein

Force vector diagram of valve

His Use of Drawing

Complete workings on 1 page

OM artery

Open & closed aortic valve
Describes Os cordis; hence non-human specimen

Mitral valve apparatus:  
N = pap m.  
F = leaflet; M = annulus  

“detialp sdroc”

? Salai
• **Mitral Stenosis.**

• Wherefore, the cadaver of the deceased having been cut up for public benefit, it was found that the ventricle of the man had so hardened in the joints toward its lowest part, that since it was able to transmit nothing from there to the inferior parts, by necessity death followed.”

Antonio Benvieni writing of the autopsy of a relative, Antonio Bruni. 15th century physician
**Effect of Rheumatic disease**

- “...and these fibres multiply like thick short tow and lengthen and wrap themselves around the chords of the membranes which close the ventricle in such a way that with ageing of the animal the orifice cannot close well and a large part of the blood ...escapes through the imperfectly closed orifice into the upper ventricle. For this reason all the spirits are insufficient in the aged and they often die whilst speaking!”
Of the papillary muscles....

- “..the papillary muscle is the primary cause of the movement of the heart, and in contracting it enlarges, and in enlarging it shortens and draws back all the muscles below and above it, and closes the gate M {Mitral valve} and shortens the distance interposed between the base and the apex of the heart, whence it comes to empty itself.”

- W19029 recto
.....some very complex views!
Cardiac twist!
To conclude.......
Relationship with Doctors!

“Endeavor to preserve thy health in which thou wilt succeed the better the more thou guardest thyself from the physicians. For their mixtures are a kind of alchemy on which there are no fewer books than there are remedies.”

..part of a paraphrase from Regimen sanitatis of Arnold of Villanova or one of the numerous modifications of that work such as the tract of Ugo Benzo, Milan 1481
“…never say you know the last word on any Human Heart!”

Henry James
Moderator band
“catena”
“anetac”
“Of the Heart, This moves of itself and does not stop unless forever...Marvellous instrument invented by the supreme Master.”

Moderator band

"catena"

"anetac"
The Bronchial Circulation & its relevance to Lung Transplantation

Paired bronchial arteries

Cartilages

bronchocoele?

An Ox heart..”
Miral valve is quadri-leaflet!
He explained thus:

…“that when the heart contracts,.. blood from the lower ventricle rushes with impetus through the cusps of the aortic valve, then forms a vortex that grows against the walls of the sinus and valve leaflets.”
Cardiac twist!