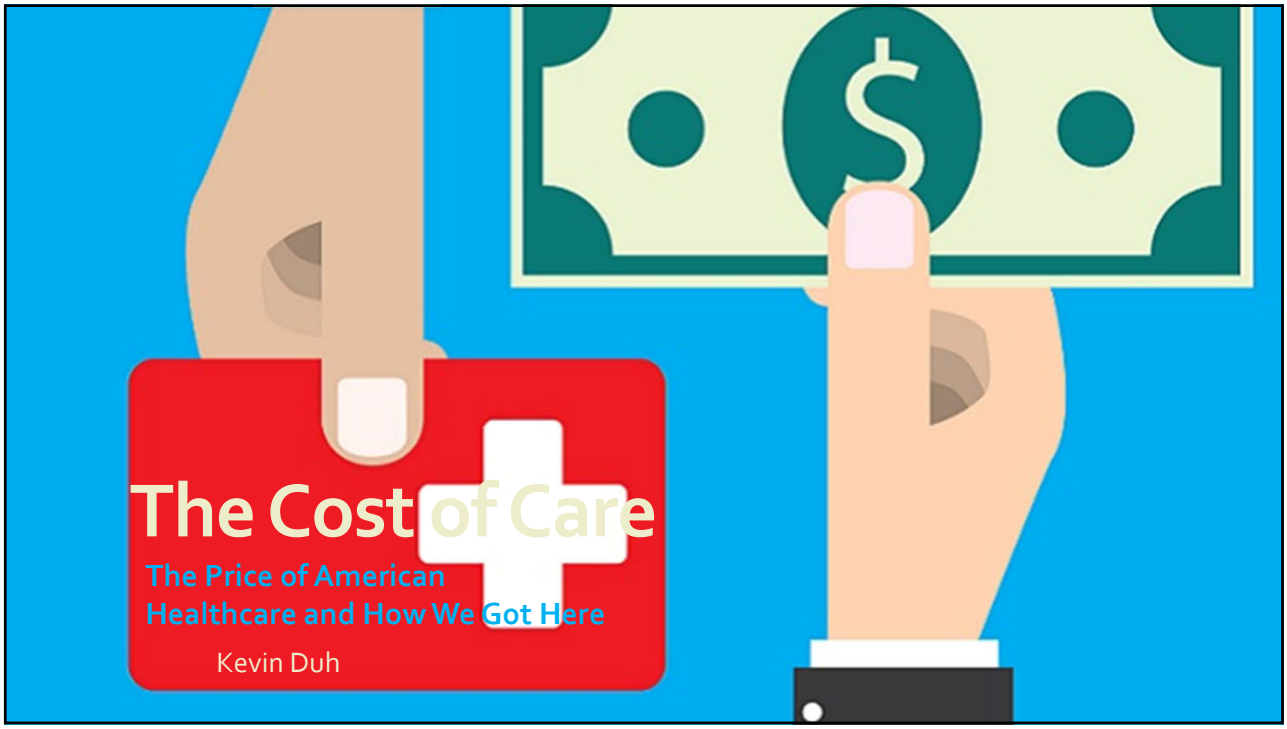

Minneapolis
Heart Institute
Foundation
GRAND ROUNDS

1

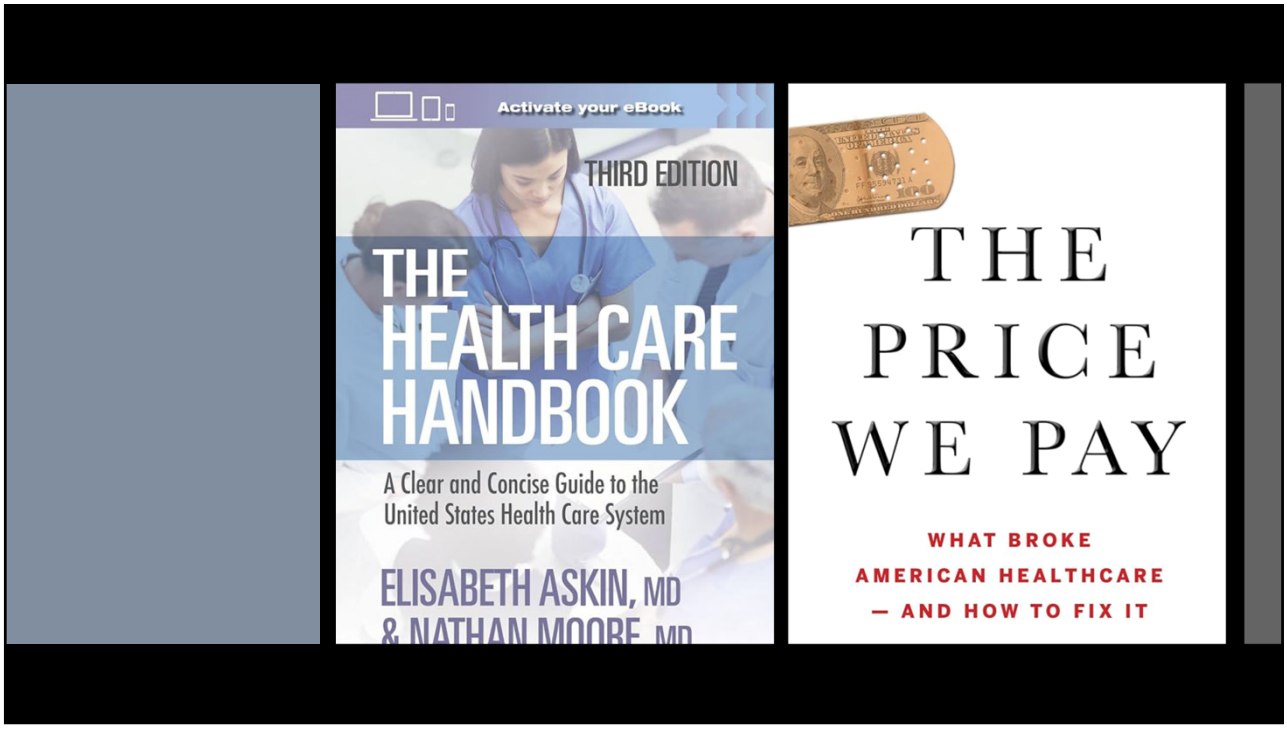

The Cost of Care
The Price of American
Healthcare and How We Got Here
Kevin Duh

2

Disclosures

- none

3



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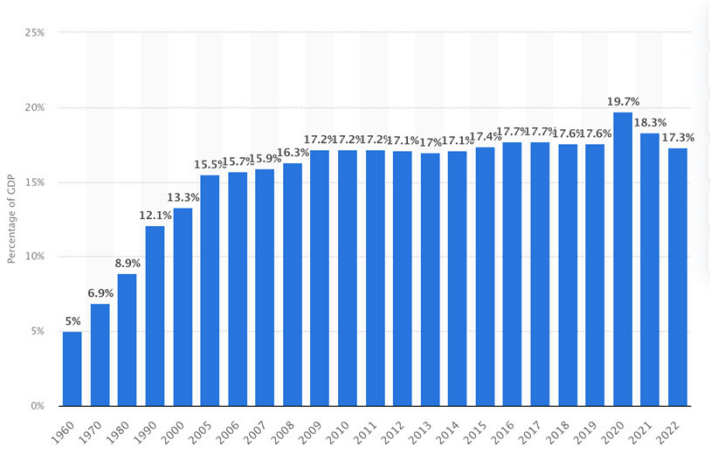
Overview

- Scope of the Problem
- Healthcare Systems
- Cost Drivers
- The ACA, in brief
- Myth-busting
- How do we get to a solution?

5

U.S. national health expenditure as percent of GDP from 1960 to 2022



Credit: Preeti Vankar, *Statista 2024*

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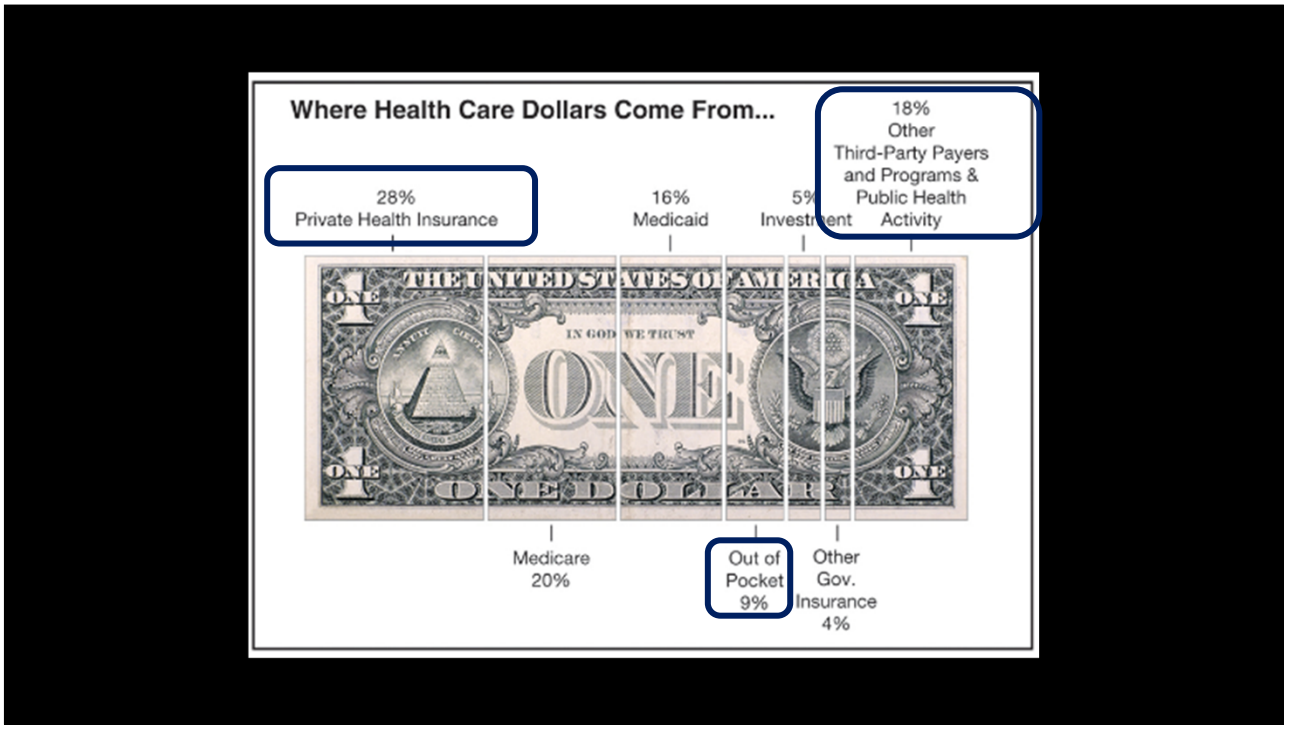
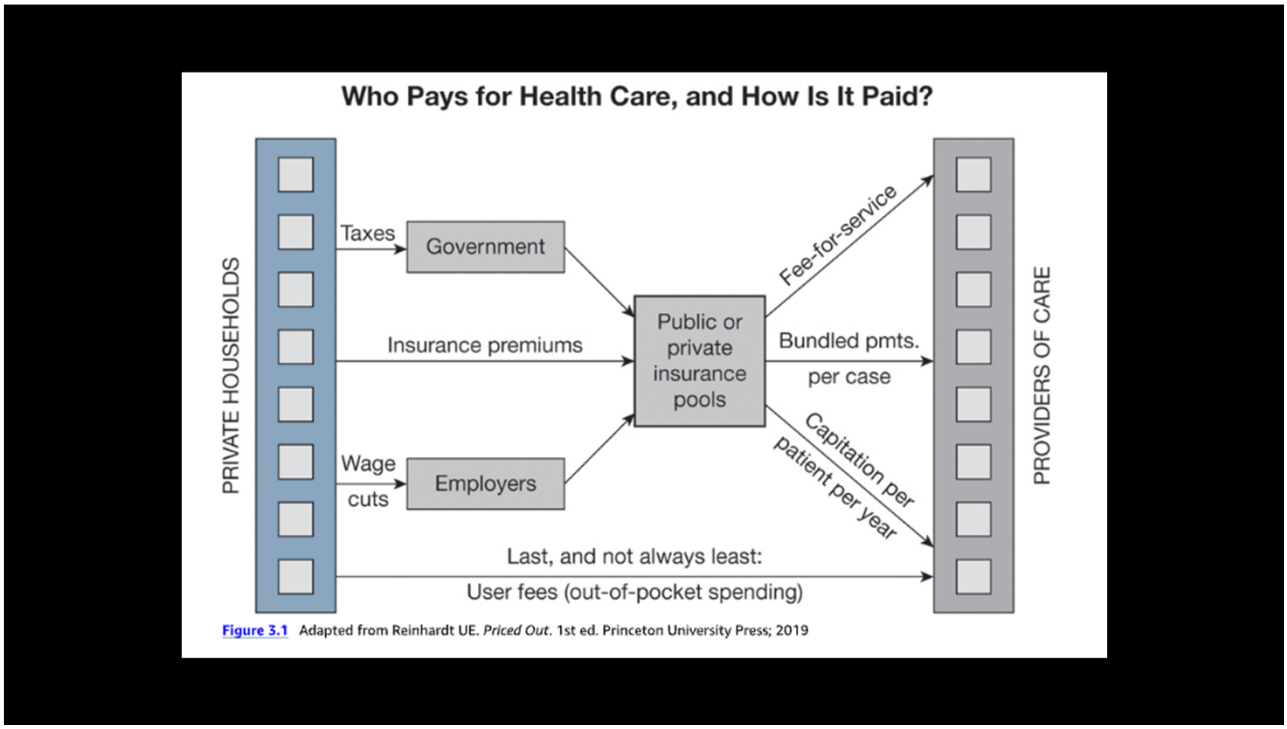

Where Health Care Dollars Come From...
28%
Private Health Insurance
16%
Medicaid
5%
Investment
18%
Other
Third-Party Payers
and Programs &
Public Health
Activity
Medicare
20%
Out of
Pocket
9%
Other
Gov.
Insurance
4%

7


...and Where They Go To
8%
Government Administration
and the Net Cost of
Health Insurance
31%
Hospital Care
8%
Prescription
Drugs
5%
Public Health
Activities
14%
Other
Physicians
and Clinics
20%
Dental
Care
3%
Investment
(Including
Noncommercial
Research)
5%
Nursing Homes
and
Long-Term Care
5%

8


Who Pays for Health Care, and How Is It Paid?
PRIVATE HOUSEHOLDS
Taxes
Government
Insurance premiums
Wage cuts
Employers
Public or private insurance pools
Fee-for-service
Bundled pmts. per case
Capitation per patient per year
Last, and not always least:
User fees (out-of-pocket spending)
PROVIDERS OF CARE
Figure 3.1 Adapted from Reinhardt UE. Priced Out. 1st ed. Princeton University Press; 2019

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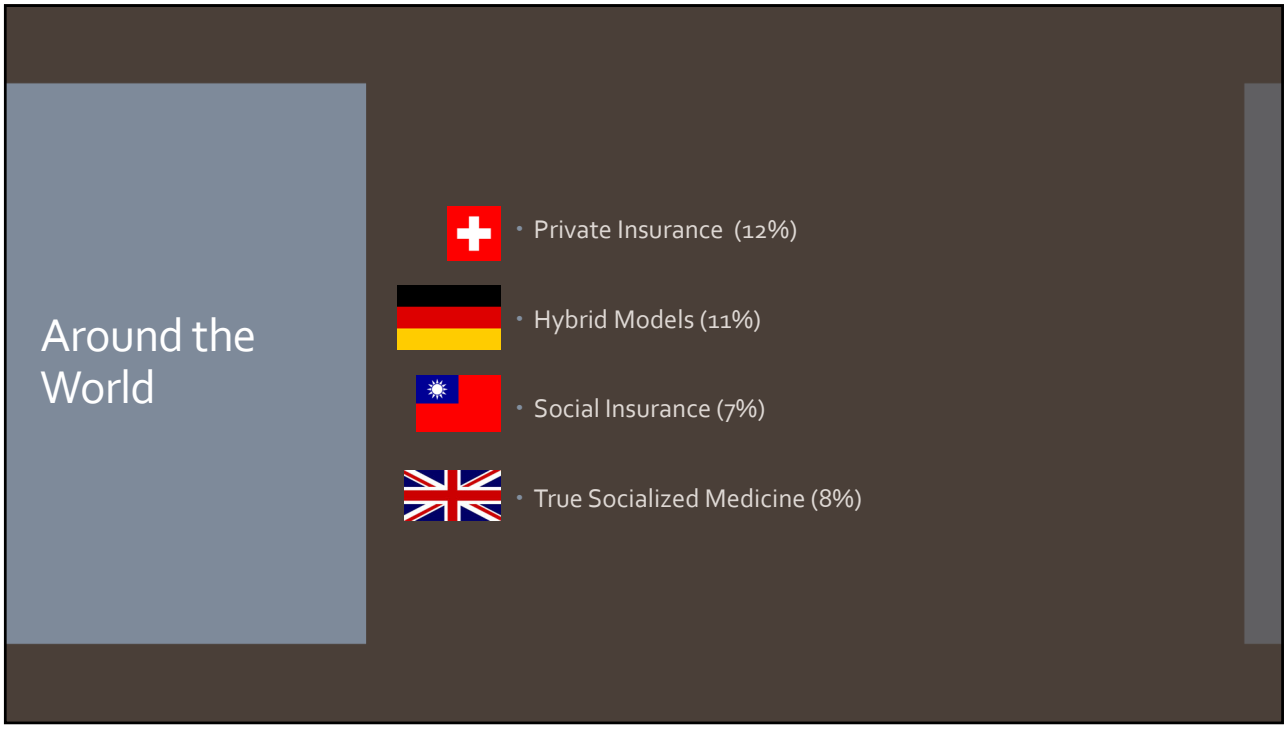
Around the World
Private Insurance (12%)
Hybrid Models (11%)
Social Insurance (7%)
True Socialized Medicine (8%)

10

Differences in the US System

- US system is a hybrid of many of the above
- All these systems have essentially universal coverage
- **Price negotiation and standardization**

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Key Drivers of Cost

Inherent in Healthcare, and Unique to the US

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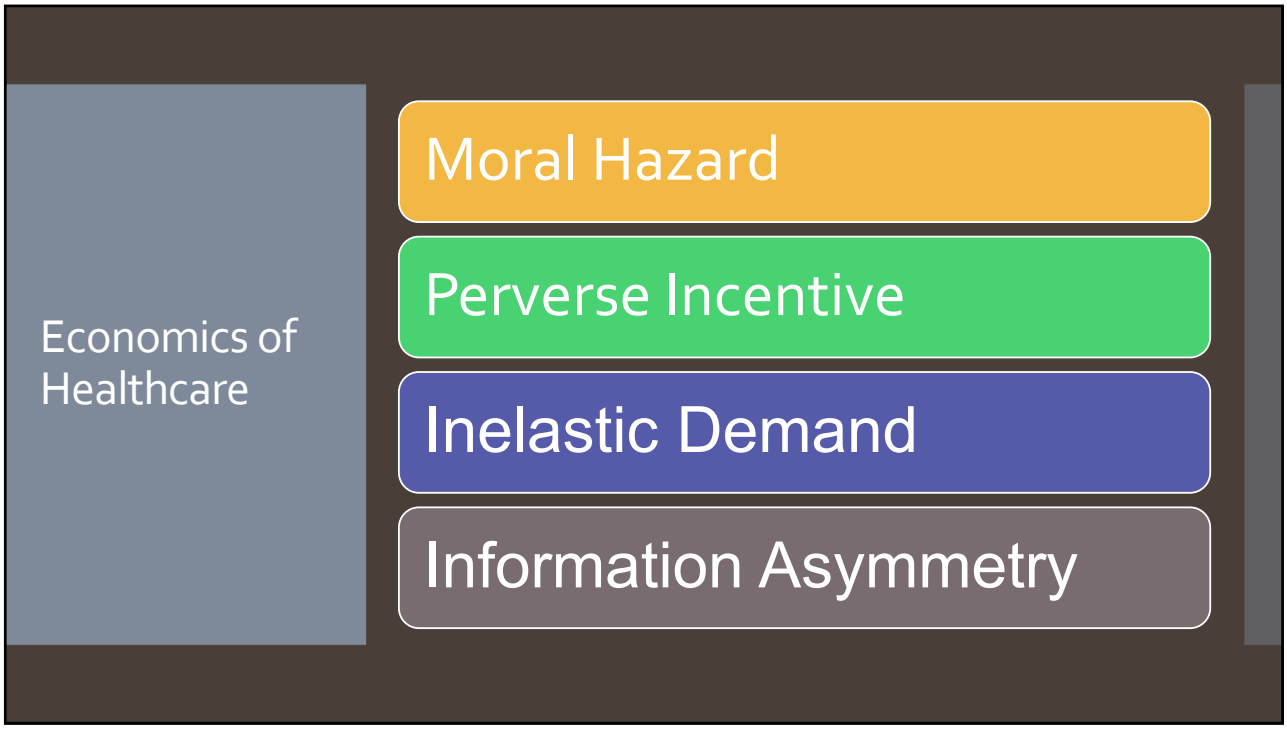
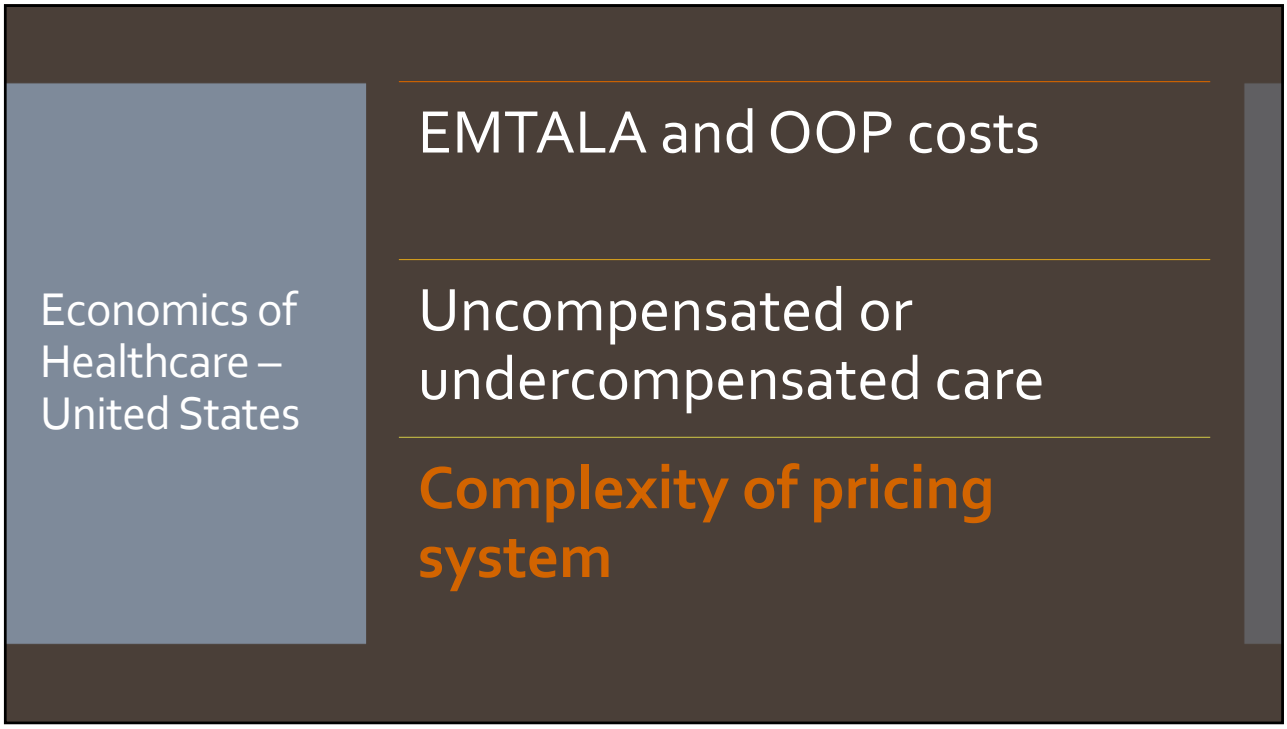
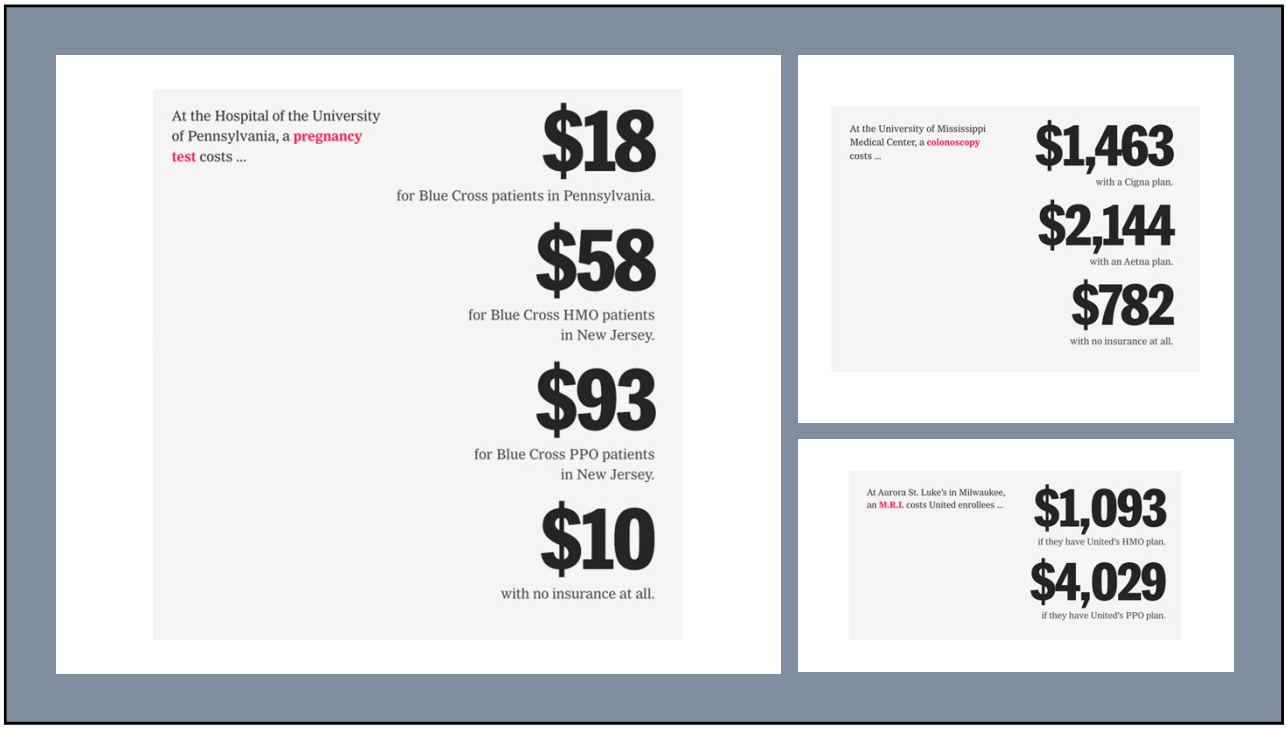

Economics of Healthcare
Moral Hazard
Perverse Incentive
Inelastic Demand
Information Asymmetry

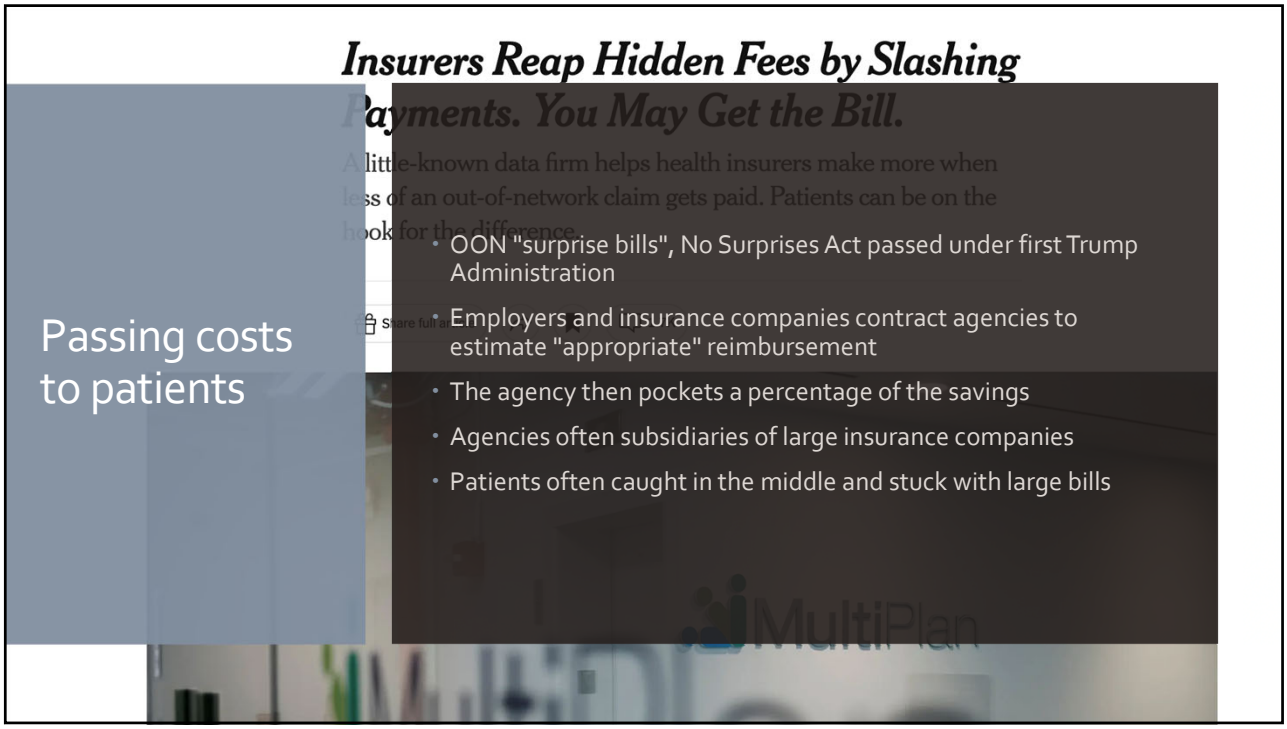
13


Economics of Healthcare – United States
EMTALA and OOP costs
Uncompensated or undercompensated care
Complexity of pricing system

14


At the Hospital of the University of Pennsylvania, a pregnancy test costs ...
$18
for Blue Cross patients in Pennsylvania.
$58
for Blue Cross HMO patients in New Jersey.
$93
for Blue Cross PPO patients in New Jersey.
$10
with no insurance at all.
At the University of Mississippi Medical Center, a colonoscopy costs ...
$1,463
with a Cigna plan.
$2,144
with an Aetna plan.
$782
with no insurance at all.
At Aurora St. Luke's in Milwaukee, an M.R.I. costs United enrollees ...
$1,093
if they have United's HMO plan.
$4,029
if they have United's PPO plan.

15


Insurers Reap Hidden Fees by Slashing Payments. You May Get the Bill.
A little-known data firm helps health insurers make more when less of an out-of-network claim gets paid. Patients can be on the hook for the difference.
Passing costs to patients
• OON "surprise bills", No Surprises Act passed under first Trump Administration
• Employers and insurance companies contract agencies to estimate "appropriate" reimbursement
• The agency then pockets a percentage of the savings
• Agencies often subsidiaries of large insurance companies
• Patients often caught in the middle and stuck with large bills
MultiPlan

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Drugs and Devices
R&D is expensive
Can cost several billion dollars to bring a drug to market
Likelihood that a drug will make it through ~14%
US subsidization of research
What do we get for the money?
Marketing ~$30 billion annually
Are the new compounds even innovative?
1998 – 2003, ~14% of 483 approved drugs were considered real improvements over prior versions
Insulin as a microcosm

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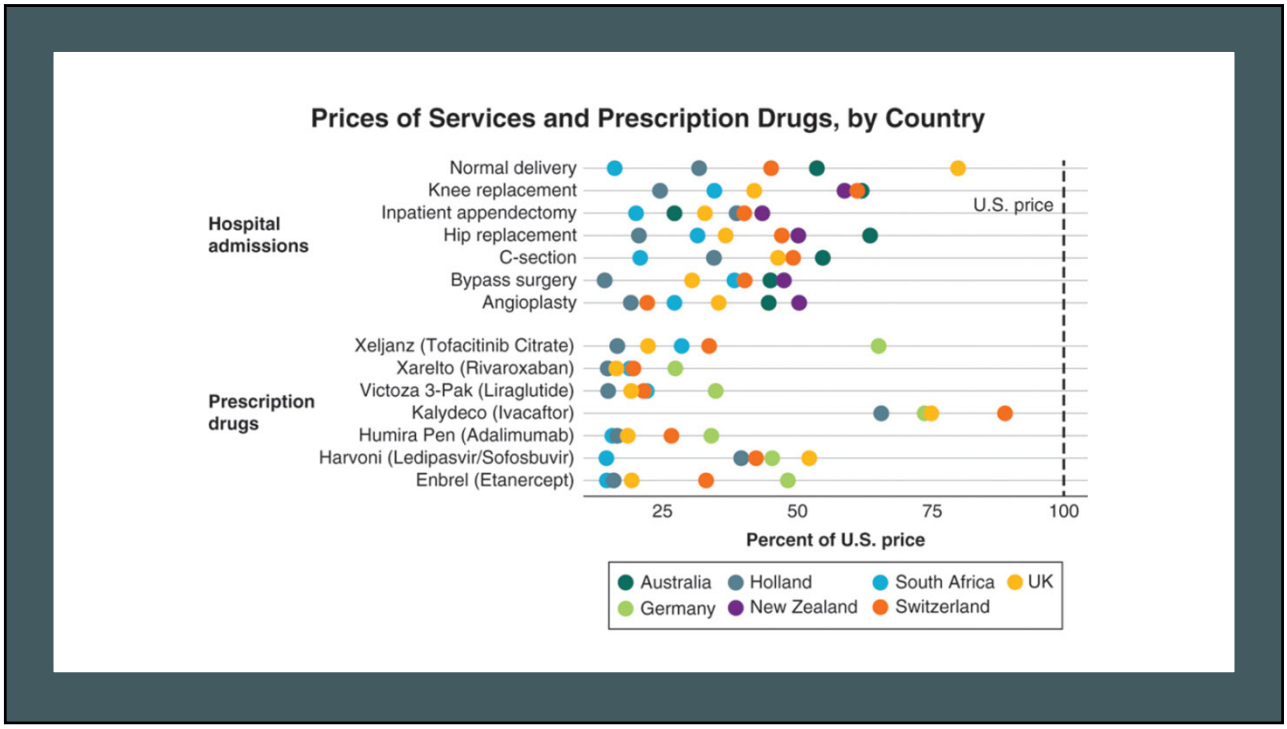
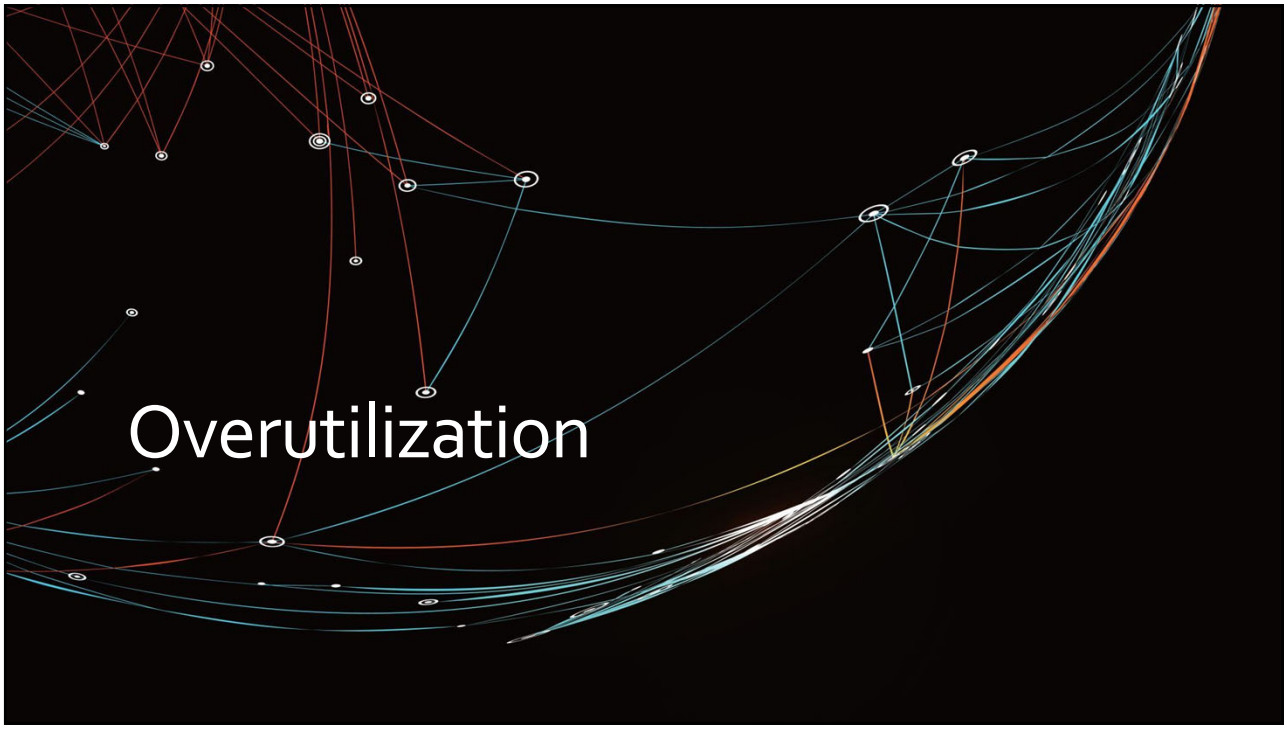

Prices of Services and Prescription Drugs, by Country
Hospital admissions
Normal delivery
Knee replacement
Inpatient appendectomy
Hip replacement
C-section
Bypass surgery
Angioplasty
U.S. price
Prescription drugs
Xeljanz (Tofacitinib Citrate)
Xarelto (Rivaroxaban)
Victoza 3-Pak (Liraglutide)
Kalydeco (Ivacaftor)
Humira Pen (Adalimumab)
Harvoni (Ledipasvir/Sofosbuvir)
Enbrel (Etanercept)
25
50
75
100
Percent of U.S. price
Australia
Holland
South Africa
UK
Germany
New Zealand
Switzerland

18



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Hotspotting: Camden Coalition

- Mission to identify the 1% of patients, the highest utilizers who account for 30-40% of spending
- Meet them on the streets, identify barriers to care, and improve prevention and social services to minimize utilization
- **RCT failed to demonstrate improvement in readmission rates**

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Overtreatment: Investigation of Stenting for Claudication

From the Society for Vascular Surgery

Overuse of early peripheral vascular interventions for claudication

Check for updates

Caitlin W. Hicks, MD, MS,[a] Courtenay M. Holscher, MD,[b] Peiqi Wang, MD, MPH,[b] James H. Black III, MD,[a] Christopher J. Abularrage, MD,[a] *and* Martin A. Makary, MD, MPH,[b,c] *Baltimore, Md*

- Investigated FFS claims of patients with first-time diagnosis of claudication 2015 – 2017
- Measured rates of PVI
- 194,974 patients total, 6286 underwent early PVI
- The median early PVI rate among physicians was 0%
- 5.6% had early PVI rate > 14%
- Conclusion: Outlier physicians accounted for high rates of early PVI in certain communities

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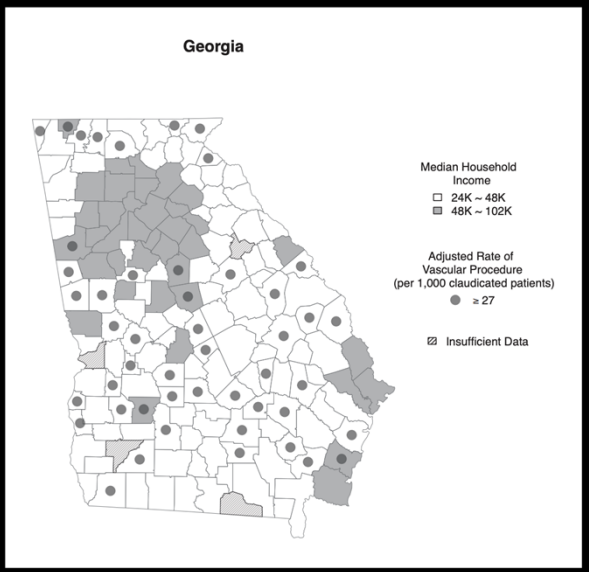
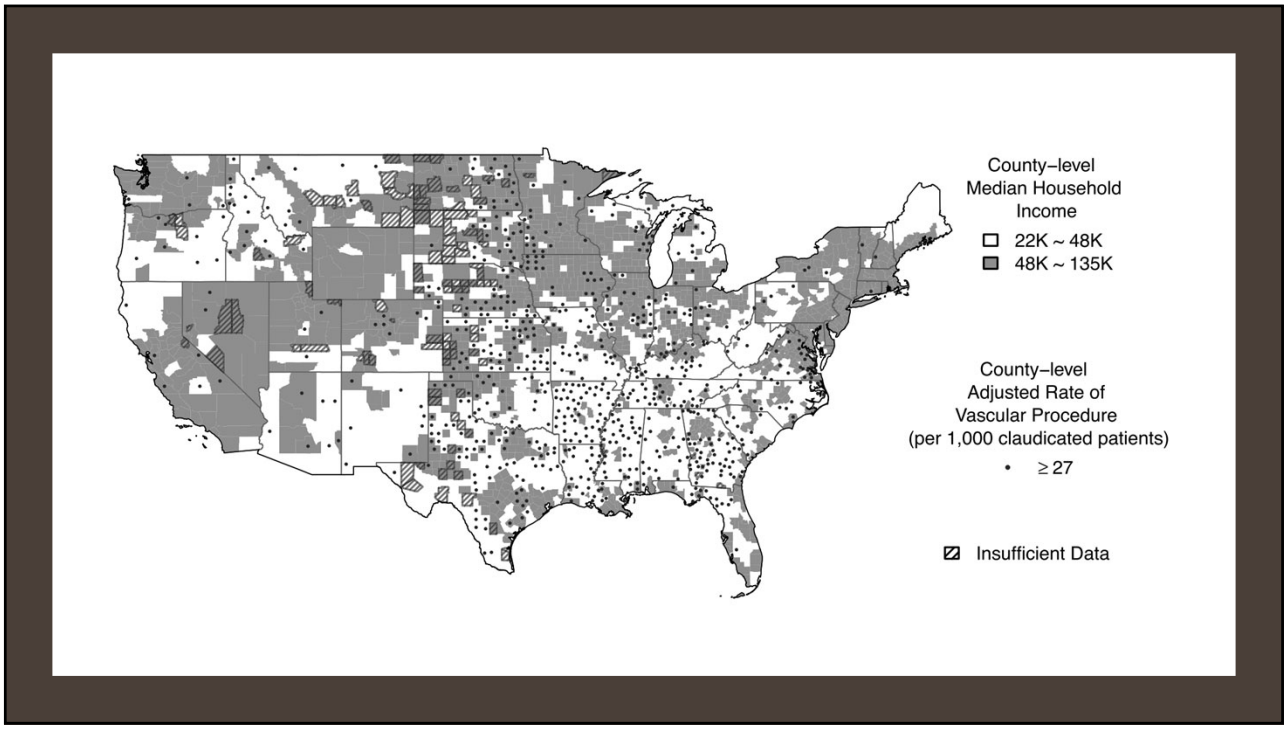


22



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The Affordable Care Act (2010)

- Key changes
  - Individual Mandate*
  - Community rating of insurance risk for premiums
  - Restriction on denial based on pre-existing conditions
  - MLR mandated at 85% for small insurers, 90% for large ones
- **Access** was the main goal
- Uninsured rate 16% to 7%*
- Cost controls also a major part, but probably less successful

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Fragmentation of Philosophy, and the Politics of Diversity

- Ideological diversity, piecemeal solutions
- Innumerable systems
- Administrative and bureaucratic complexity
- $$$

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Myth: Social Spending will Control Healthcare Costs

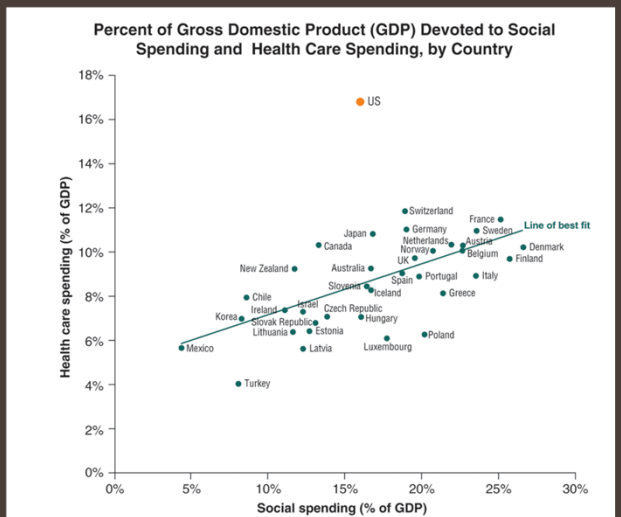

Figure 3.13 Adapted from Papanicolas I, Woskie LR, Orlander D, Orav EJ, Jha AK. The relationship between health spending and social spending in high-income countries: how

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Myth: Free market solutions alone can solve this

The air ambulance example

- Historically, hospitals owned emergency transport vehicles and employed personnel and operated at cost
- Trend towards privatization has led to an excess of transport and air ambulance companies
- *This has led to higher, not lower prices*
- There is no ability for true competition, and often little choice in the matter for the person being transported

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Myth: Nobody is expected to pay chargemaster prices

- High deductible plans
- Out-of-network bills
- Litigation practices against patients by hospitals
- Where does the price of complications go?

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Myth (sort of): Alternative Payments will Fix the Problem

- **Lies, damned lies, and statistics**
- Example: Readmission rates
- ACA included intense scrutiny of 6 diagnoses (COPD, CABG, CHF, TKR, PNA, MI) and their readmission rates
- Readmission rates improved..
- ..but ~60% improvement attributed to risk-adjustment and intense coding
- Intense use of "observation" status
- CMMS penalizes readmission rates up to 15x worse than mortality

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What to do?

- ***"It's the Prices, Stupid"***
- Price transparency and price negotiation reform
- Reduce fragmentation
- Understand change can be painful
- Waste sometimes = employment, but are we providing **value** to the patient, and to society?
- **The buck stops here**

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Askin, E and N Moore. *The Health Care Handbook, 3E: A Clear and Concise Guide to the US Health System*. Philadelphia, Wolters Kluwer 2024.

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Hamby, C. "Insurance Companies Reap Hidden Fees by Slashing Payments. You May Get the Bill." *New York Times* April 7, 2024.

Vankar, P. "U.S. Health Expenditure as percent of GDP from 1960 to 2022." *Statista* February 16, 2024.

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History of the Cardiovascular System and Early Surgical Advances

Hayden Moore, DO

Vascular and Endovascular Surgery Fellow

May 4th, 2026

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Overview

- Ancient ideas about the cardiovascular system
- Galen and Galenic cardiovascular physiology
- The Renaissance period and key breakthroughs that led to change
- William Harvey and how his theory ushered in the modern era of medicine
- The Hunter brothers and Rudolph Matas and their contributions to early vascular surgery
- Brief review of 20th century advances in vascular anastomosis and aortic surgery

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The Ebers Papyrus (2000 BC)

- The Ebers Papyrus is an ancient Egyptian medical text
- One of the oldest and most comprehensive records of Egyptian Medicine

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The Ebers Papyrus (2000 BC)

- Extending from the heart were *mtw (Vessels)*
- Unidirectional distributive system carrying blood **and other bodily fluids**
- Recognized some connection between the lungs and the heart
  - "as for the air that enters at the nose, it enters to the heart and lungs, and they convey [it] to the whole body"
- Recognized that the peripheral pulse resulted from the heart and that assessing the beat of the heart and vessels provided insight into the patient's condition

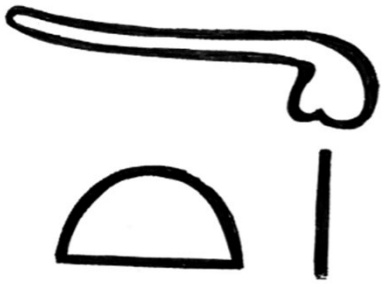

Fig 3. Hieroglyph for *mtw*, or vessel, rendered by Wa Liu. The erect phallus has phonetic, not symbolic significance.

35

The Ebers Papyrus (2000 BC)

- Provides the oldest description of arterial aneurysms:
  - "When thou considereth a swelling of the vessels on any part of the man's body and thou findst it globular [and] firm under thine fingers when going [pulsating?]...then thou shalt say: 'this is a vessel swelling, a disorder I will treat. It is the vessels that cause it. It originates from an injury upon the vessel.' **Then thou shalt apply to it treatment with the knife; this [the knife] is heated in fire; the bleeding will not be considerable.**"

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Galen (129 AD)

- Born in Pergamum, Asia Minor (Bergama, Turkey)
- Started medical education at age 16
- **157 AD** – Returned to Pergamum where he was appointed surgeon to the gladiators
- **162 AD** – Traveled to Rome and quickly established his reputation as a leading medical authority
- Appointed physician to Emperor Marcus Aurelius (121 AD – 180 AD)
- Died approximately 216 AD

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Before Galen

- **Hippocrates (460 BC)** and his contemporaries were the first to offer sophisticated reasoning in medicine, rejecting a role for divine causation
- **Aristotle (384 BC)** believed that the heart was the center of the physiological mechanism, the seat of the soul and the source of all blood vessels
- **Praxagoras (340 BC)** was the first to differentiate between arteries and veins
- **Herophilus (3rd century BC)** recognized that arteries have thicker coats than veins (noting the exception in the lung)

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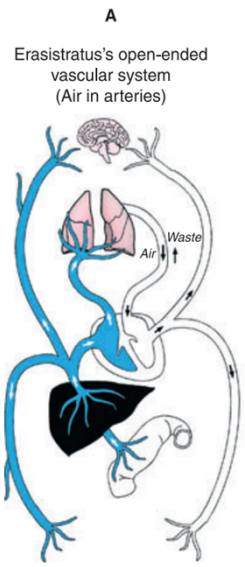
Before Galen



- **Erasistratus (3rd century BC)**
  - He considered the heart to be the source of both veins and arteries.
  - He believed that arteries normally contain air
  - He observed that when punctured, an artery bleeds. To explain this paradox, he suggested that blood moves from veins to arteries through invisible anastomoses when the arteries are emptied of air

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Galen (129 AD)

- Aristotle had introduced formal logic as a means of generating scientific knowledge.
- Galen employed deductive logic to arrive at many of his conclusion
- According to Galenic historian, Vivian Nutton, [Galens] conclusions are almost always correctly derived from his premises:
  1. If the heart is hotter than other organs, then it is the source of innate heat.
  2. But the heart is hotter than other organs.
  3. Therefore, the heart is the source of innate heat

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Galenic Physiology

- Four essential humors of the body
  - Blood
  - Black bile
  - Yellow bile
  - Phlegm
- Natural spirit (the blood) derived from food and drink was overlaid with vital spirit (pneuma) derived from atmospheric air

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Galenic Physiology

- Veins contain blood
  1. Food is turned to chyle in the stomach
  2. Chyle is absorbed by intestines and taken to the liver via the portal vein
  3. Blood is created in the liver and charged with natural spirit
  4. The liver is the source of all veins
  5. Blood moves centrifugally from the center to the periphery
  6. Each part of the body attracts and retains only enough blood for its immediate requirements
  7. Blood is consumed to nourish the tissues/organs
- A portion of blood nourishes the lungs via the right ventricle

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Galenic Physiology

- Respiration cools the innate heat and yields vital spirit
  1. Air is concocted in the lungs to form pneuma
  2. Pneuma is transmitted to the left ventricle via the pulmonary vein
  3. It cools innated heat from the heart and mixes with venous blood
     - **Venous blood passes from the right to left ventricle via small invisible pores within the interventricular septum**
  4. Noxious vapors, generated as a byproduct of the innate heat, are expelled back into the pulmonary veins and out through the lungs
     - Retrograde movement in the pulmonary vein made possible by the mitral valve

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Galenic Physiology

- Arteries contain air and blood
- The arterial pulse is an intrinsic property of the blood vessel
  - Arteries are not expended because they are filled. Rather, they are filled because they are expanded.

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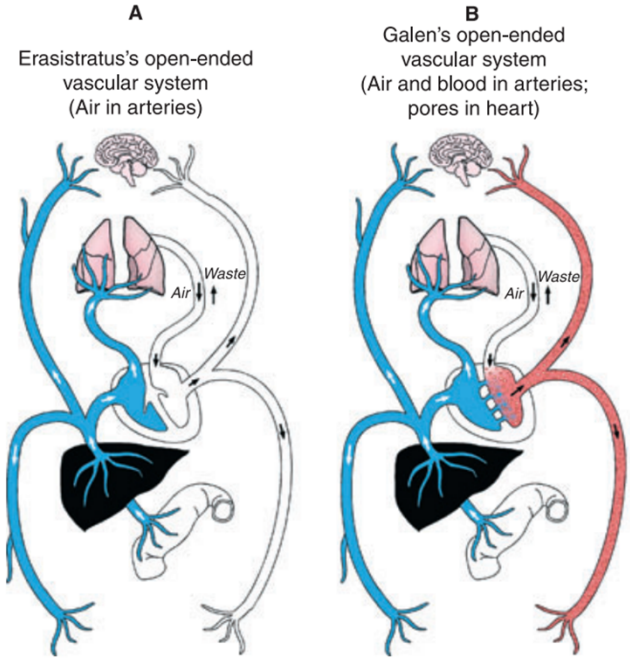

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Antyllus (2nd century AD)

- Greek surgeon practicing in Rome
- Earliest record of attempted treatment of aneurysms (recorded 4th century AD in the works of Oribasius)
  - Antyllus applied ligatures to the arteries that entered and left the aneurysm and then cut into the aneurysm sac, evacuated the contents, and packed the cavity.
    - "We decline exceptionally big aneurysms, but we will operate as follows on aneurysms in the extremities, the limbs and the head."
  - Antyllus did not resect the aneurysm sac.
    - "Those who tie the artery, as I advise, at each extremity, but amputate the intervening dilated part, perform a dangerous operation. The violent tension of the arterial pneuma often displaces the ligatures."

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The Dark Ages and Middle Ages

- The fall of the Roman Empire was followed by a long period of time (500–1400 AD) in which the **scholarly tradition was closely intertwined with and controlled by the Church**
- His teachings aligned with Christian doctrine and its theological status rendered it immune to challenge

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Henri de Mondeville (1260 – 1320)

- French Anatomist and Surgeon
- Served as surgeon to King Philip the Fair of France (1301) and Louis X (1314)
- Professor of Anatomy and Surgery at the University of Montpellier
  - Conducted the first unauthorized human dissection
  - His efforts lead to legalization of human dissection in 1340
- First Frenchman to author a surgical text, *La Chirurgie,* in 1306
- **The first surgeon to practice ligation of arteries to control hemorrhage**, which was documented in the chapter on amputation of limbs

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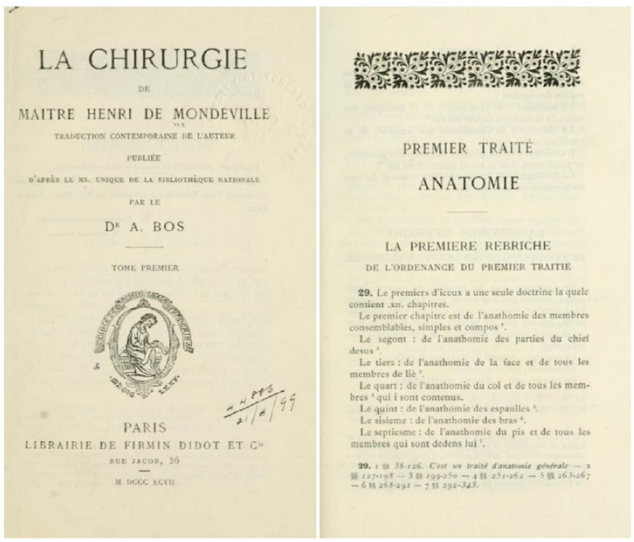

LA CHIRURGIE

DE

MAITRE HENRI DE MONDEVILLE

TRADUCTION CONTEMPORAINE DE L'AUTEUR

PUBLIÉE

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PAR LE

Dr A. BOS

TOME PREMIER

PARIS

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RUE JACOB, 56

M DCCC XCVII

PREMIER TRAITÉ

ANATOMIE

LA PREMIERE REBRICHE

DE L'ORDENANCE DU PREMIER TRAITIE

29. Le premiers d'iceux a une seule doctrine la quele contient xii. chapitres.

Le premier chapitre est de l'anathomie des membres conemblables, simples et compos [1].

Le segont : de l'anathomie des parties du chief desus [2].

Le tiers : de l'anathomie de la face et de tous les membres de lié [3].

Le quart : de l'anathomie du col et de tous les membres [4] qui i sont contenus.

Le quint : de l'anathomie des espaulles [5].

Le sisieme : de l'anathomie des bras [6].

Le septiesme : de l'anathomie du pis et de tous les membres qui sont dedens lui [7].

29. 1 §§ 38-126. *C'est un traité d'anatomie générale* — 2 §§ 127-198 — 3 §§ 199-250 — 4 §§ 251-262 — 5 §§ 263-267 — 6 §§ 268-291 — 7 §§ 292-343.

Fig. 4. Images showing the cover page and the first page of the section on anatomy from an edition of *La Chirurgi* Maitre Henri de Mondeville, which was edited by Dr. A Bos and published in 1897 by Librairie De Firmin Didot et Paris.

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Fig 1. A medieval anatomy lesson is portrayed in this painting from Johannes de Ketham's Fascicolo di Medicina (1491). The professor is seated high above the body and directs the dissection, although he gazes at the viewer, not the corpse. The green-frocked man is actually performing the dissection. His waist-length garment distinguishes him as belonging to a lower social class. Medical students, in long red and black robes, gather around to observe.

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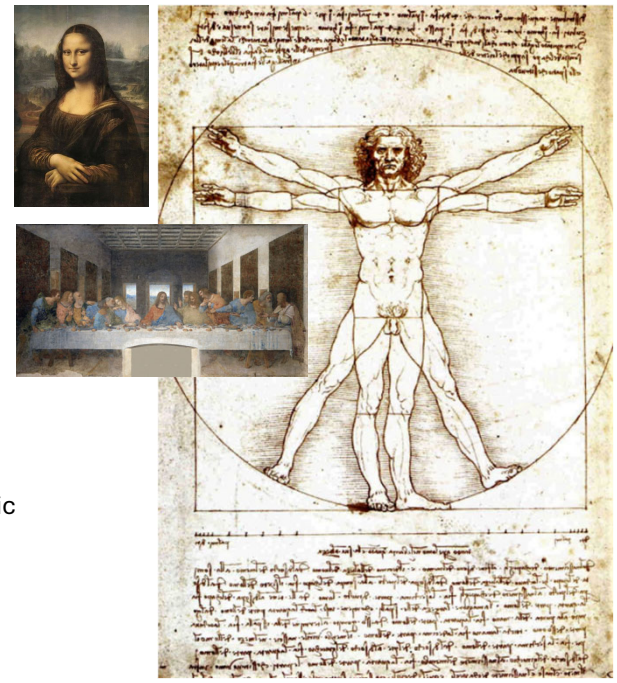
The Renaissance

- Human dissection began in the late 13th century at the University of Bologna, Italy
- **Leonardo da Vinci (1452-1519)**
  - Described the heart as a muscle, contradicting Galen
  - Identified the atria as heart chambers
  - Provided a description of atherosclerotic coronary arteries



51

Andreas Vesalius (1514-1564)

- Professor of Anatomy and Surgery at the University of Padua, Italy
- Insisted on the importance of actual dissection, by both the teacher and pupil, when learning anatomy
- Published *De Human Corporis Fabrica Septem Libri*, or Seven Books on the Fabric of the Human Body (1543)
  - Book III of *Fabrica* describes the vascular system
  - Provided the earliest compete rendering of the vascular system

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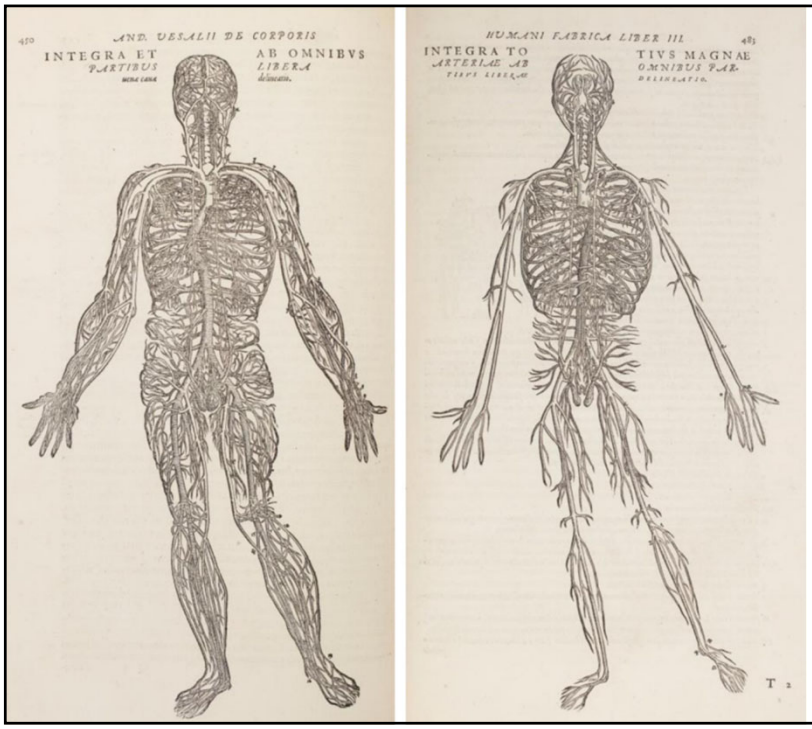

Fig 3. **Plates 44 and 45 of Fabrica. Left, Plate 44 displays the veins of the body and (right) plate 45 shows the arteries.** The additional detail and attention in plate 44 indicate the importance of the veins over the arteries in the 16th century. As the images display and O'Malley and Saunders describe, Vesalius did not have a perfect grasp of vascular anatomy. In plate 44, the right renal vein is mistakenly superior to the left (a relationship more common in animals), the azygos is abnormally dilated, and the veins at the base of the neck follow a nonhuman mammalian pattern. The continuity of the vena cava reflected the contemporary understanding of the role of the atria (considered part of the vessel and not of the heart). In plate 45, the aortic arch appears as a bovine variant, the lateral thoracic artery is disproportionately large for humans, and the branches of the internal and external carotid arteries are confused.7 These picayune errors aside, Vesalius' mapping of the vasculature was a quantum leap beyond anything previously produced and served as the standard reference point for generations of physicians.

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Andreas Vesalius (1514-1564)

- Cardiovascular anatomy contributions:
  1. First description of the pancreaticoduodenal veins
  2. First description of the right and left gastroepiploic veins
  3. First to recognize the inferior mesenteric vein linked to the portal, not caval, system
  4. Identified the heart as the origin of the inferior vena cava (previously thought to be the liver)
  5. **First to diagnose a ruptured aneurysm of the aorta, which he later confirmed by autopsy**
- Most significantly, in his second edition of Fabrica in 1555, Vesalius demonstrated the **impermeability** of the cardiac septum

54

"many things present themselves here that call into doubt the ordinary conclusions of anatomists, but it would take too long to consider them, and I have decided not to alter my account piecemeal - although at the same time I am far from satisfied."

-Andreas Vesalius

55

Realdo Colombo (1516-1559)

- Italian anatomist and student of Vesalius
- Provided an anatomical account of the pulmonary transit of blood in 1559
- He based his theory on three observations:
  - The pulmonary vein was full of blood
  - He was unable to demonstrate pores in the interventricular septum
  - He recognized that the heart valves were competent

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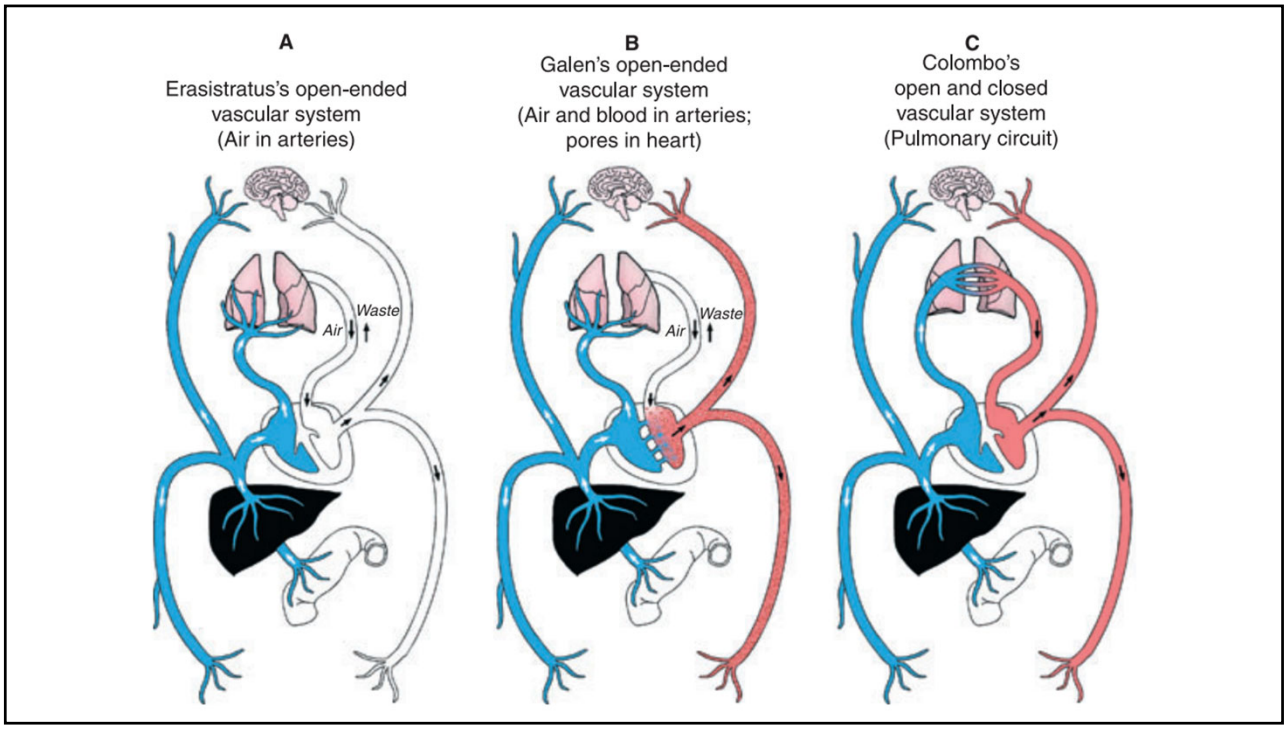


57

Ambroise Paré II (1510-1590)

- Known as the greatest surgeon during the Renaissance
- French military surgeon
- First to choose an amputation site well above the gangrenous area
- Popularized ligature in favor of boiling oil for cauterization in amputation
- Published in his "*Dix Livres de La Chirugie*" (1564)

58

Girolamo Fabrizio (also known as Fabricius, 1537-1619)

- Professor of Anatomy at the University of Padua (Italy) when William Harvey studied there
- Identified venous valves in 1574 and published a description of them in 1603
- Fabricius proposed that the valves function to slow the centrifugal flow of blood to the periphery

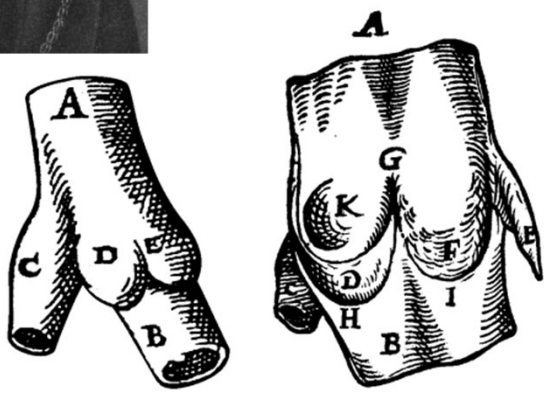
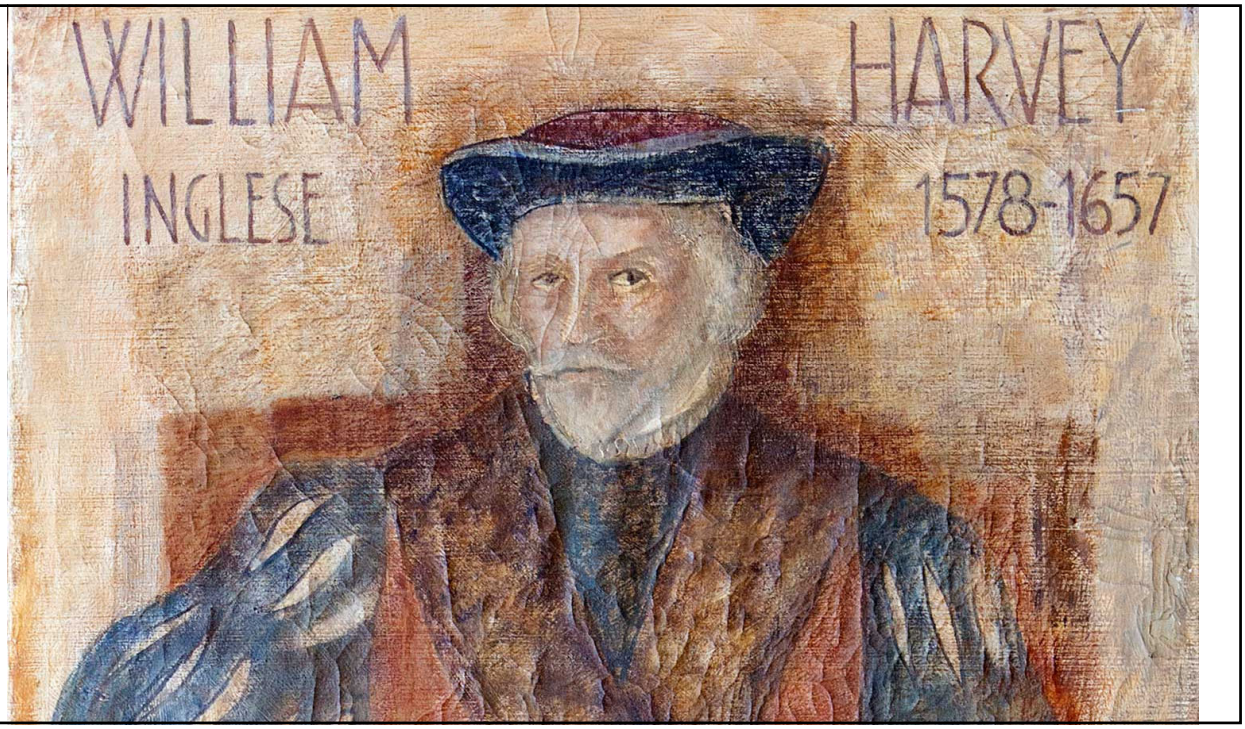


Fig 5. The first drawings of a venous valve by Salomon Alberti, published in 1585.[34]

59



60

William Harvey (1578-1657)

- Born in Kent, England
- Studied medicine at Padua in Italy (1597)
  - Studied under Fabricius
  - Galileo Galilei occupied the chair of mathematics
- Returned to England and lectured at the Royal College of Physicians for 6 years
- Lecture notes from 1616 attest to the early seeds of his theories on circulation
- Published a 72-page book entitled *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (Anatomical Exercises on the Motion of the Heart and Blood in Animals)

61

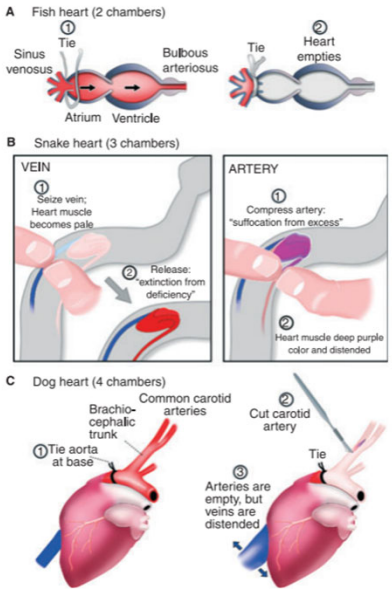
William Harvey (1578-1657)

- Arterial pulse is due to impulse of blood from the left ventricle
  - Contrast to what the Ancients believed, contraction (systole) of the heart occurs simultaneously with dilation (systole) of the arteries
  - Attributed arterial diastole to inherent property of vessel (elastic recoil)
- Against the right ventricle serving merely to supply nourishment to the lungs
- Against the left ventricle serving for egress and regress of spirits
- Rejected invisible interventricular septal pores
- Accepted pulmonary transit of blood

62

William Harvey (1578-1657)

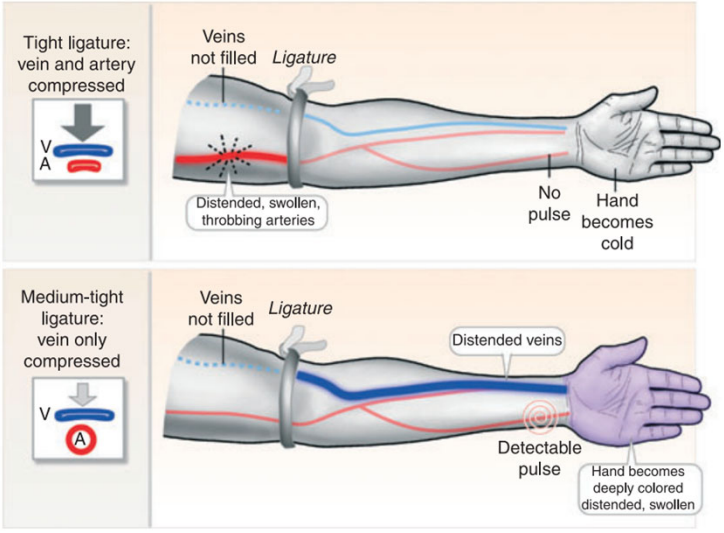
- Quantity of blood is too great to be explained by open system of blood vessels
  - Found that the left ventricle held up to 2 ounces of blood
  - Assumed different ejection fraction (1/4, 1/5, 1/6, or 1/8)
  - Multiplied the stoke volume by the heart rated (which he estimated to be 33 per minute)
  - Values underestimated cardiac output, but exceeded the total volume of blood in the body
- Blood must continuously return to the heart



63

William Harvey (1578-1657)

- Harvey demonstrated that blood enters a limb by arteries and returns from it by veins
- Venous valves promote centripetal flow of blood from the lesser to the greater veins



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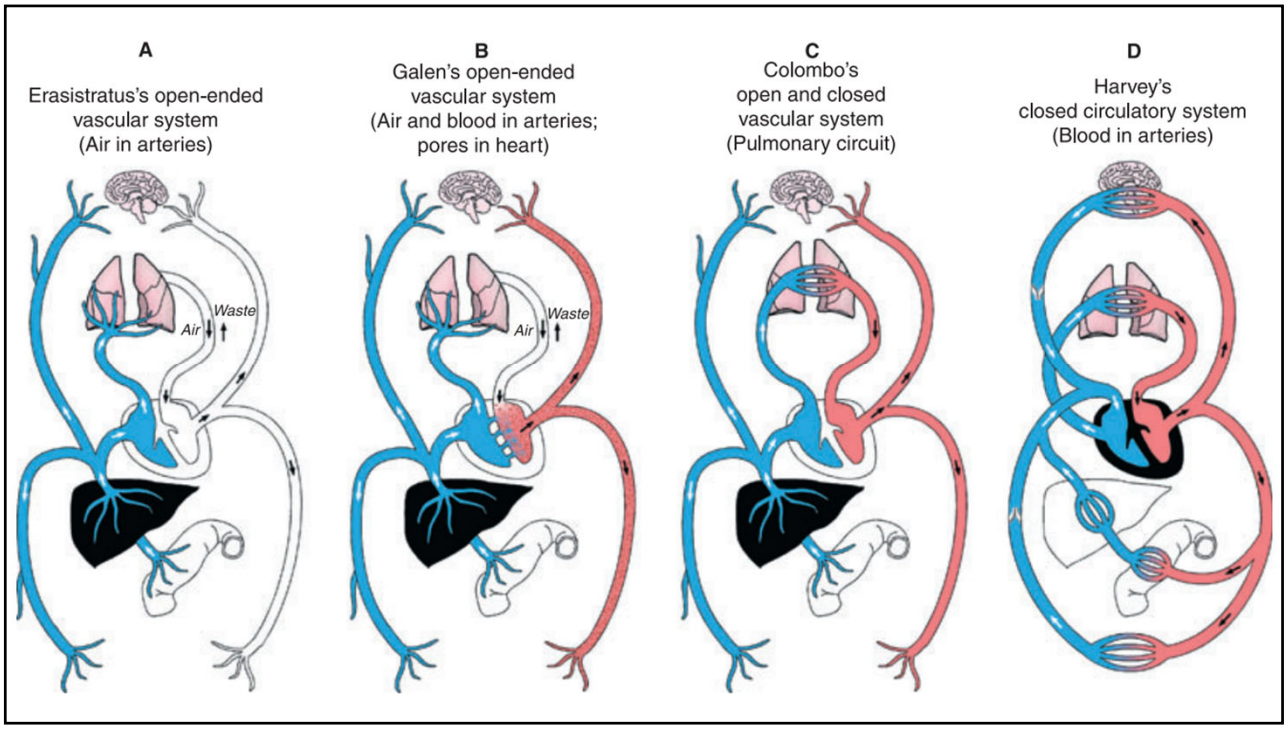


65

William Harvey (1578-1657)

- Harvey's theory of blood circulation is widely recognized as the foundation for modern medicine
- Harvey's model for circulation remained controversial until Marcello Malpighi discovered capillaries in 1661
- Harvey benefited from key observations made by his predecessors
- Both Harvey and Galen may have been influenced by technology of their age

66

William Hunter (1718-1783)

- Scottish surgeon and anatomist
- 1768 – Established an anatomy school in London
- Became interested in aneurysms and made numerous observation and descriptions as early as 1733
  - *"When I first saw him (1749), there was an oblong swelling between the cartilages of the second and third ribs of the right side .... Its pulsation was strong, and perceptible even to the eye, and corresponded with the pulse in the wrist."*
  - Mr. Isaac Bradwell died in 1752 of a ruptured thoracic aneurysm

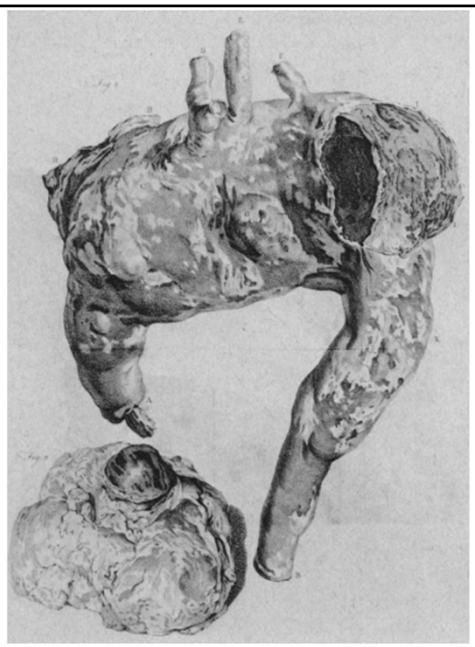
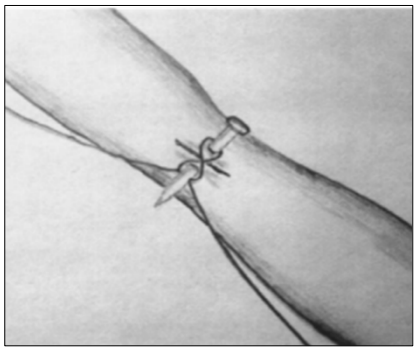


Fig 2.—Jan Van Rymsdyck's large, fold-out drawing of ruptured thoracic aortic aneurysm described in *History of Aneurysms of the Aorta With Some Remarks on Aneurysms in General*, by William Hunter, 1757 (Trent Collection, Duke University).

67

William Hunter (1718-1783)

- 1761 – Reported and described the first vascular suture to the Society of Physician
- Messieurs Lambert and Hallowell of Newcastle-on-Tyne, England placed a steel pin through the orifice in an artery and obliterated the opening by wrapping a thread around it
- Hunter published this report in the *Medical Observations and Inquires* in 1762
  - "If it should be found by experience that a large artery, when wounded, may be healed up by this kind of suture, without becoming impervious, it would be an important discovery in surgery."



68

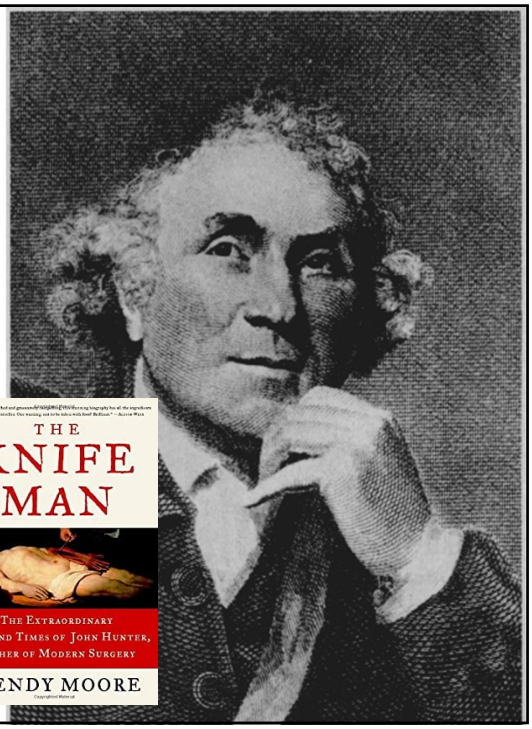
John Hunter (1728-1793)

- Scottish anatomist and surgeon
- Brother to William Hunter
- Obtained and dissected the cadavers at his brother's anatomy school
- Introduced surgery to the scientific method
- Studied the development of collateral circulation of occluded arteries
  - Ligated the external carotid artery of a deer in Richmond Park, London and noted microcirculation had reestablished one week later

69

John Hunter (1728-1793)

- Hunter based his later vascular procedures on rational ideas derived from prior animal experiments
  - Ligation of the femoral artery at a distance from the disease aneurysmal sac minimized arterial erosion and postoperative hemorrhage
  - Placing occluding ligatures in the thigh rather than the popliteal fossa minimizes disruption of valuable collaterals
- 1785 – Performed his famous operation for popliteal aneurysm on a 45-year-old coachman



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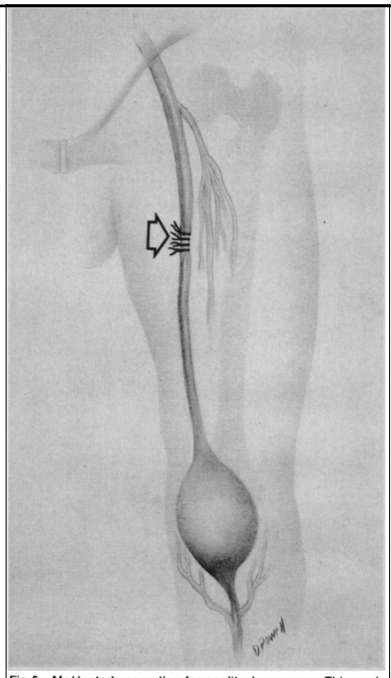


Fig 5.—Mr Hunter's operation for popliteal aneurysm. This modern drawing shows four individual arterial ligatures in Hunter canal. Note development of adequate collateral channels.

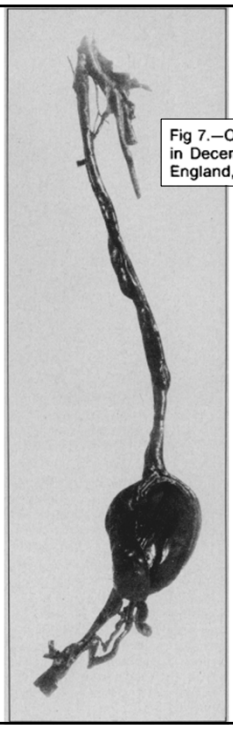


Fig 7.—Original specimen of coachman's popliteal aneurysm. Operation was performed in December 1785 at St George's Hospital in London (Royal College of Surgeons of England, Hunterian Museum).

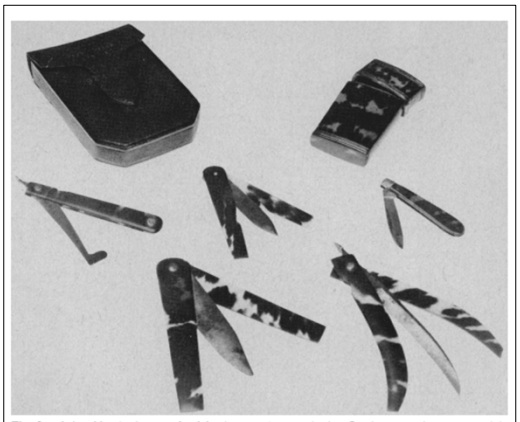
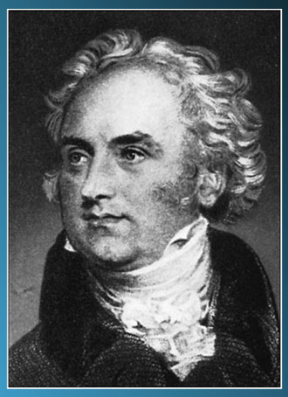


Fig 6.—John Hunter's surgical instruments, made by Savigny and preserved in Hunterian Museum. Similar set was destroyed in London blitz in 1941 (Royal College of Surgeons of England, Hunterian Museum).

71

Sir Astley Cooper (1768-1841)



- English Surgeon
- Studied surgery under Henry Cline, a former student of John Hunter
- Developed the extraperitoneal approach to exposing the iliac arteries for proximal ligation of a femoral aneurysm
- 1817 – First recorded ligation of the aorta
  - Performed for a ruptured iliac artery aneurysm
  - Patient died 40 hours later

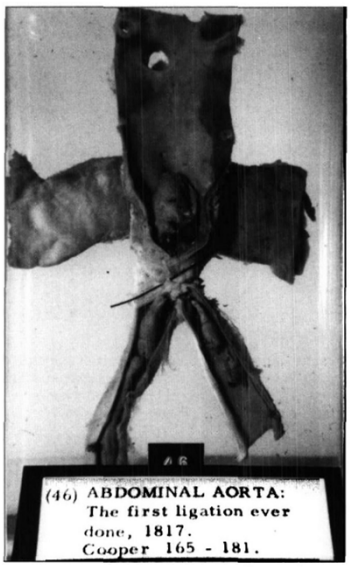
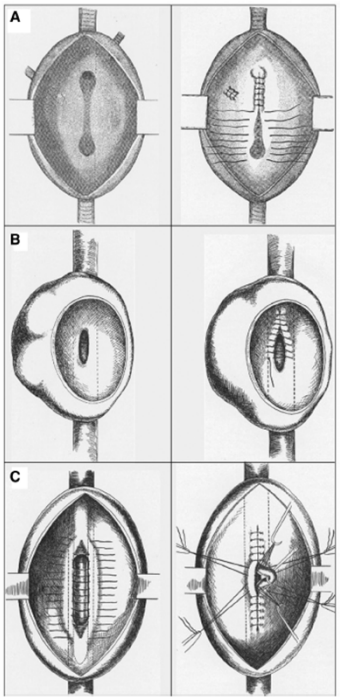


Figure 1 The specimen of Sir Astley Cooper's ligation of abdominal aorta. This is preserved in the exhibition case of Cooper specimens in the Gordon Museum at Guy's Hospital

72

Rudolph Matas (1860-1957)

- 1888 – Rudolph Matas performed his famous endoaneurysmorrhaphy in on a traumatic brachial artery aneurysm
- Three basic types: obliterative, restorative, and reconstructive
- William Osler called Matas the "father of vascular surgery
- 1938 – Isaac Bigger performed the first successful endoaneurysmorrhaphy on a traumatic abdominal aortic aneurysm



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The Vascular Anastomosis

- 1889 – Alexander Jassinowsky describes an arterial repair not including the innermost media and intimal layers
- 1896 – Mathieu Juboulay used interrupted U-stiches to coapt the intimal surface
- 1899 – Julius Dorfler performed a continuous suturing method that incorporated all layers of the vessel wall
- 1902 – Alexis Carrell first publishes on the vascular anastomosis
  - Pioneered the triangulation method
  - Used Vaseline-coated silk
  - Promoted gentle handling of the tissue and eversion technique
  - Awarded the Nobel Prize in 1912
- Rene Leriche studied under Carrel and taught Jean Kunlin
- 1948 – Jean Kunlin performs the first femoral popliteal bypass using saphenous vein graft

74

Protamine and Heparin

- Protamine was discovered by Swiss biochemist Friedrich Miescher in the late 19th century
  - Isolated from salmon sperm
- 1916 – Heparin was isolated from dog liver by a second-year medical student at John's Hopkins University named Jay McLean
- 1930 – Heparin was purified and clinical use began
- Protamine's ability to neutralize heparin was identified shortly after

75

Arteriography

- 1895 – Wilhelm Konrad Roentgen discovered X-rays
  - Received the Nobel Prize in 1901
- 1923 – Barney Brooks performed the first angiography by injecting sodium iodide to investigated the femoropopliteal system
- 1929 – Reynaldo do Santos performed the first translumbar aortography

76

Early Open Aortic Surgery

- 1951 – Charles Dubost in Paris performed the first elective resection of an abdominal aortic aneurysm with homograft replacement
- 1953 – Henry Bahnson performed the first successful repair of a ruptured abdominal aortic aneurysm with homograft
- 1953 – Michael DeBakey and Denton Cooley performed the first successful resection and graft of a fusiform thoracic aneurysm
- 1954 – DeBakey worked with textile engineer, Thomas Edman, to develop a machine to build a Dacron knitting machine
- 1955 – Edward Etheredge performed the first thoracoabdominal aneurysm repair with homograft
- 1966 – Oscar Creech combined the endoaneurysmorrhaphy technique of Matas with graft replacement
- 1970s – Stanley Crawford refined the "Clamp-and-Sew" technique that would become standard

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Questions?

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