

WORLDWIDE, CARDIOVASCULAR DISEASE AFFECTS THE LIVES OF HUNDREDS OF MILLIONS. DEDICATED CARDIONERDS EVERYWHERE ARE WORKING HARD TO FIGHT THIS GLOBAL EPIDEMIC.



A STUDY IN CYAN

A CARDIONERDS COMIC

BY: AHMED GHONEEM, MD

THIS IS ONE THEIR STORIES.

GOOD MORNING, MY DEAR FRIEND. BELIEVE IT OR NOT, I NEED *YOUR* HELP WITH A CASE.

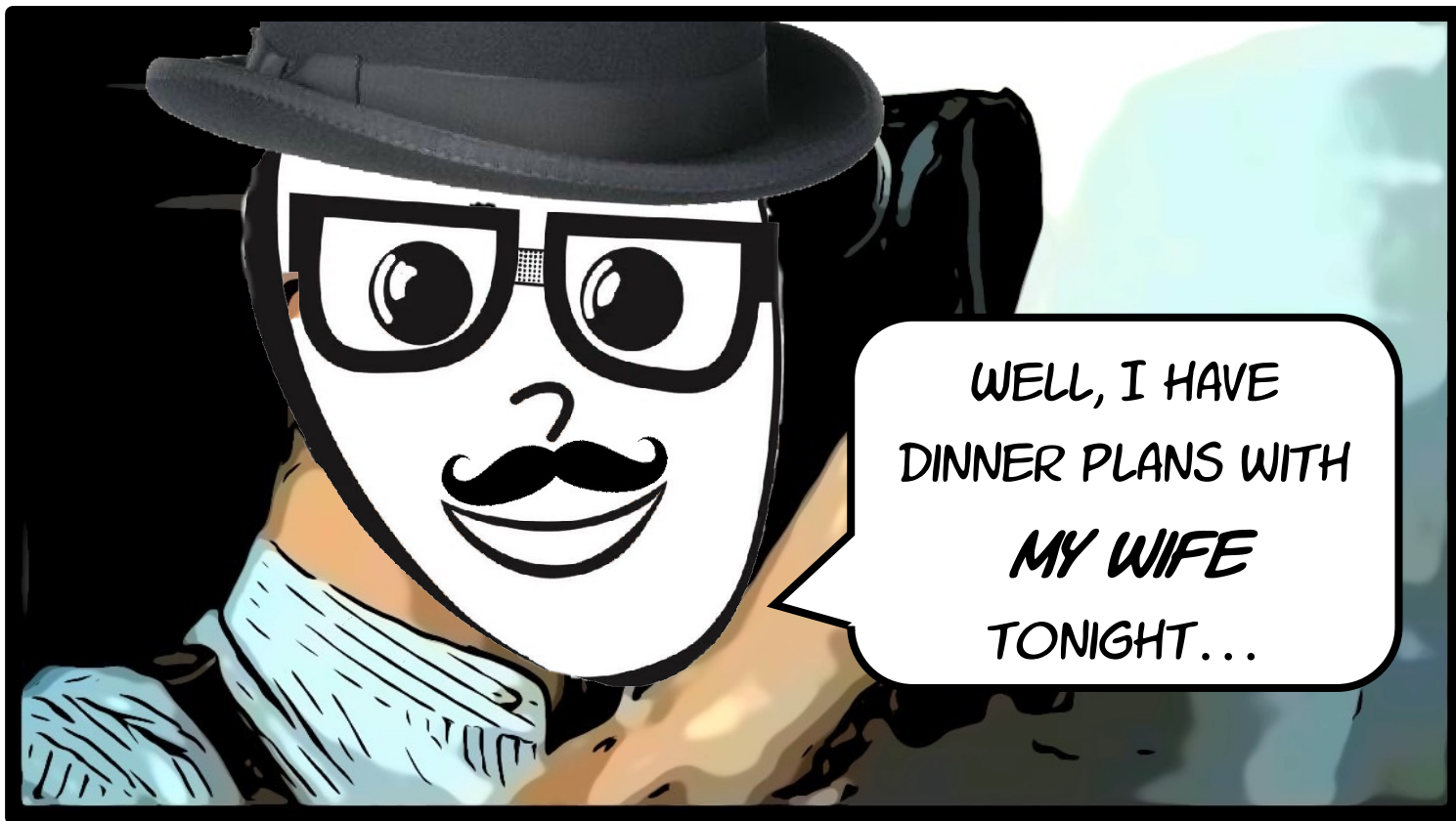
THE WORLD'S GREATEST DETECTIVE NEEDS *MY* HELP? WHAT HAS THE WORLD COME TO?

THIS IS A MISSING PERSON CASE INVOLVING A PHYSICIAN SUCH AS YOURSELF, *DR. VIYAS DEE*, WHO WAS LAST SEEN IN HIS OFFICE FRIDAY EVENING.

HIS ASSISTANT CLAIMS THAT DR. VIYAS HAD MENTIONED HE WOULD *STAY BACK* TO FINISH SOME PAPERWORK + ASKED HER TO LEAVE FOR THE DAY *AROUND 6PM*.

COME MONDAY MORNING, SHE FOUND THE OFFICE IN DISARRAY AND THERE WERE *BURNT PAPERS* IN THE FIREPLACE. THEY APPEAR TO BE PATIENT NOTES THE GOOD DOCTOR JOTTED DOWN.

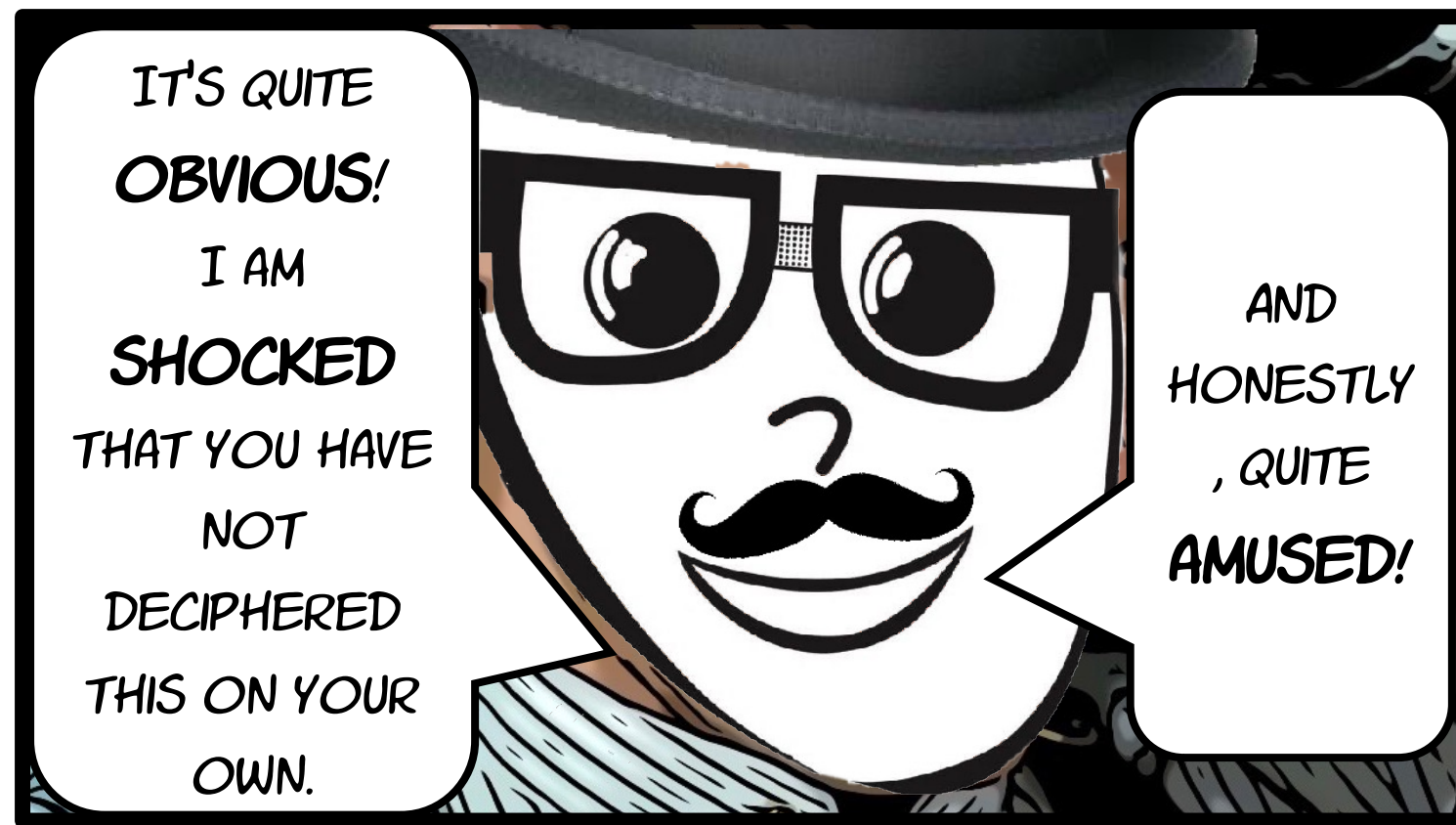
I NEED YOUR *MEDICAL KNOWLEDGE* TO MAKE SENSE OF WHAT IS WRITTEN IN THOSE BURNT NOTES. FINDING THIS *MYSTERY PATIENT* COULD LEAD US TO THE WHEREABOUTS OF DR. VIYAS!





DR. VIYAS WROTE "VSD", WHICH I KNOW IS VENTRICULAR SEPTAL DEFECT.

BUT THERE WAS SOMETHING ELSE WRITTEN AFTER THAT.. WHAT DO YOU MAKE OF IT?



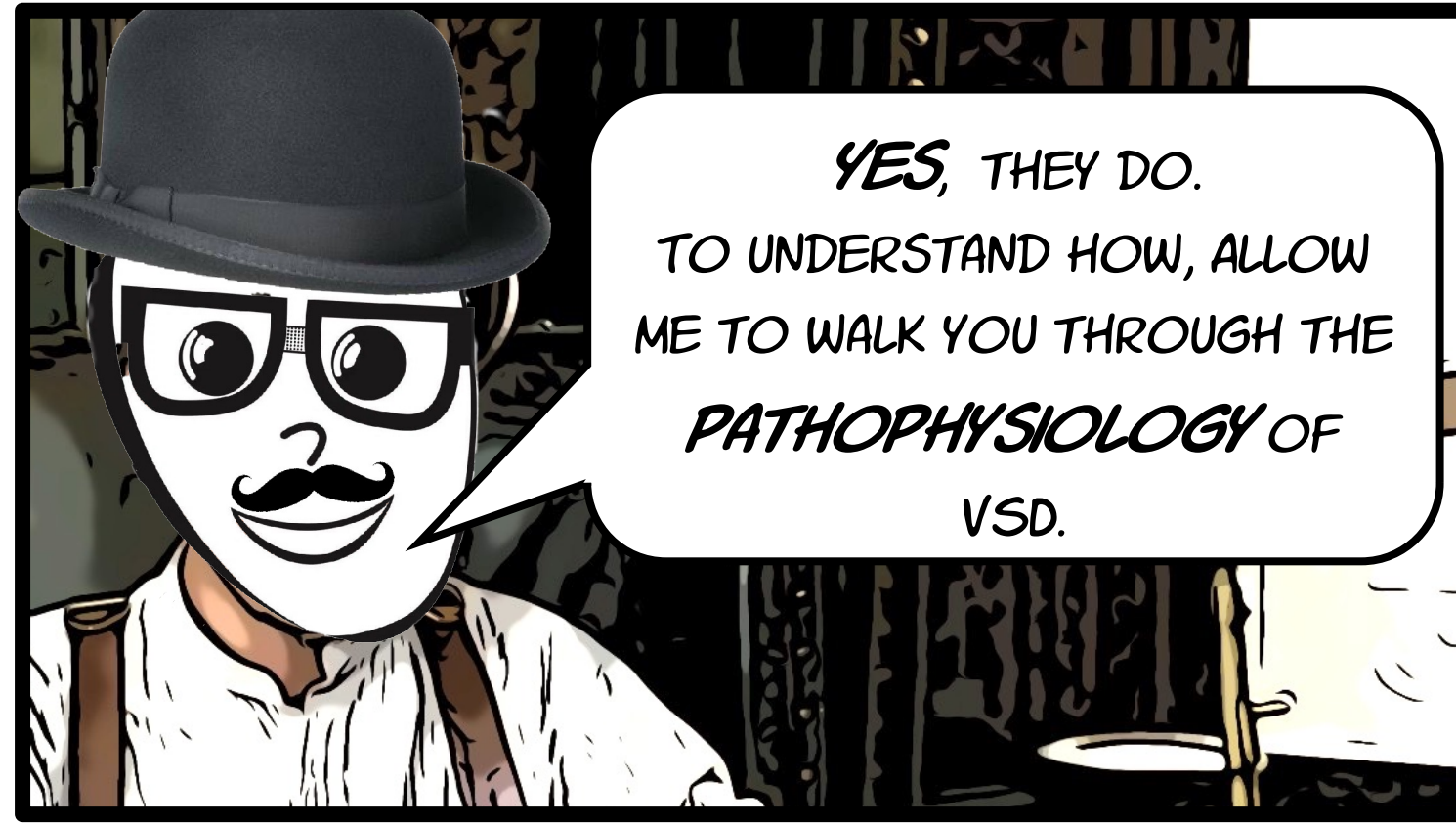
IT'S QUITE OBVIOUS! I AM SHOCKED THAT YOU HAVE NOT DECIPHERED THIS ON YOUR OWN.

AND HONESTLY , QUITE AMUSED!



HA HA ... GLAD YOU 'VE HAD YOUR FUN

NOW , DO THESE NOTES HELP IN IDENTIFYING OUR SUSPECT?



YES, THEY DO. TO UNDERSTAND HOW, ALLOW ME TO WALK YOU THROUGH THE PATHOPHYSIOLOGY OF VSD.

VSD IS A **NON-CYANOTIC** CONGENITAL HEART DISEASE, CHARACTERIZED BY AN **ABNORMAL COMMUNICATION** BETWEEN THE RIGHT AND LEFT VENTRICLES

RV 15-30

LV 100-140

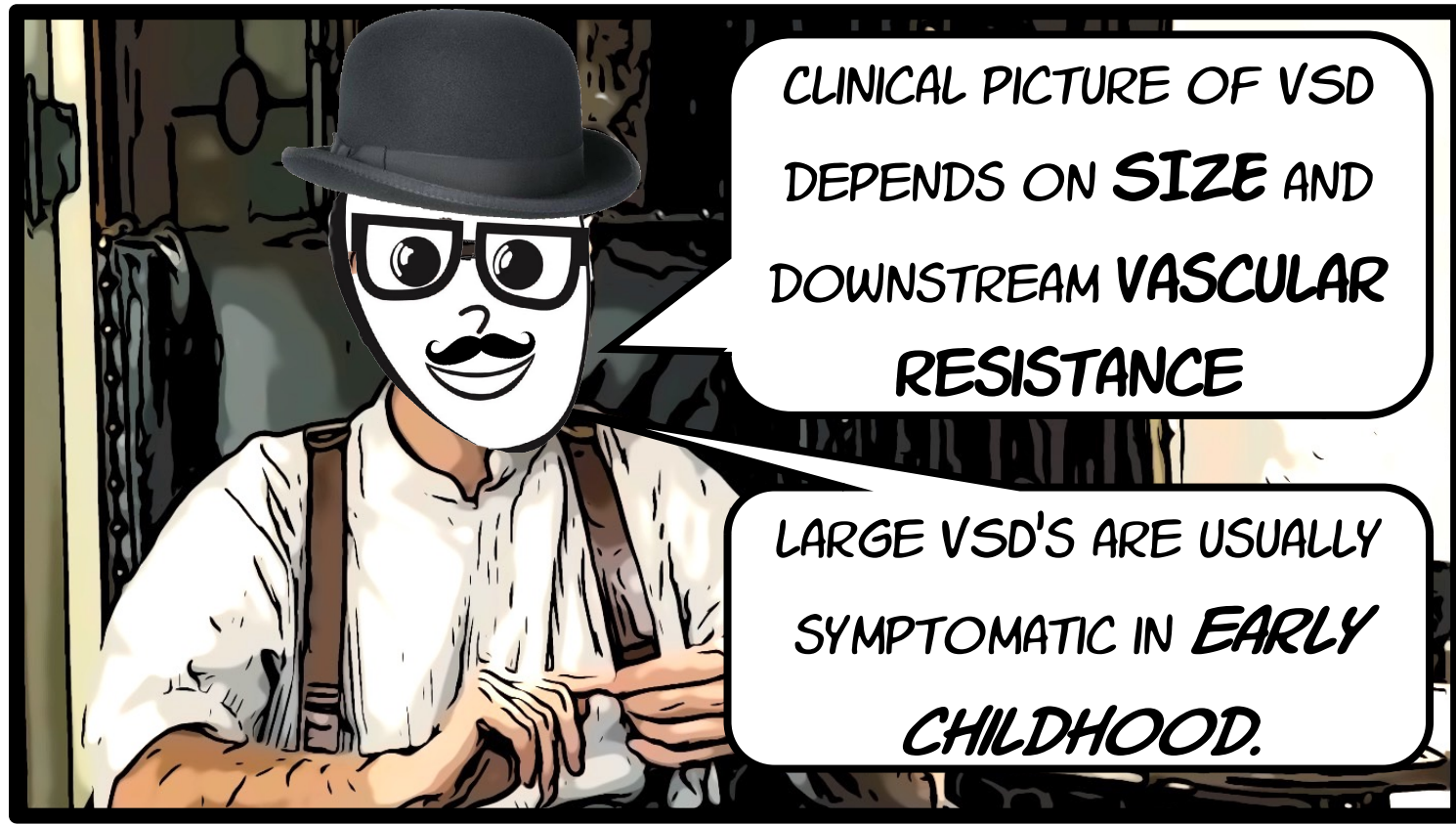
RV 2-8

LV 3-12

DURING **DIASTOLE**, PRESSURES IN THE LV AND RV AREN'T THAT DIFFERENT, SO **MINIMAL BLOOD FLOWS** ACROSS THE VSD.

DURING **SYSTOLE**, THE PRESSURE IN THE LV **EXCEEDS** THAT OF THE RV AND BLOOD FLOWS ACROSS THE VSD, LEADING TO A **LEFT-TO-RIGHT SHUNT**.

THIS ALSO LEADS TO THE CHARACTERISTIC **HOLOSYSTOLIC MURMUR** ON AUSCULTATION.

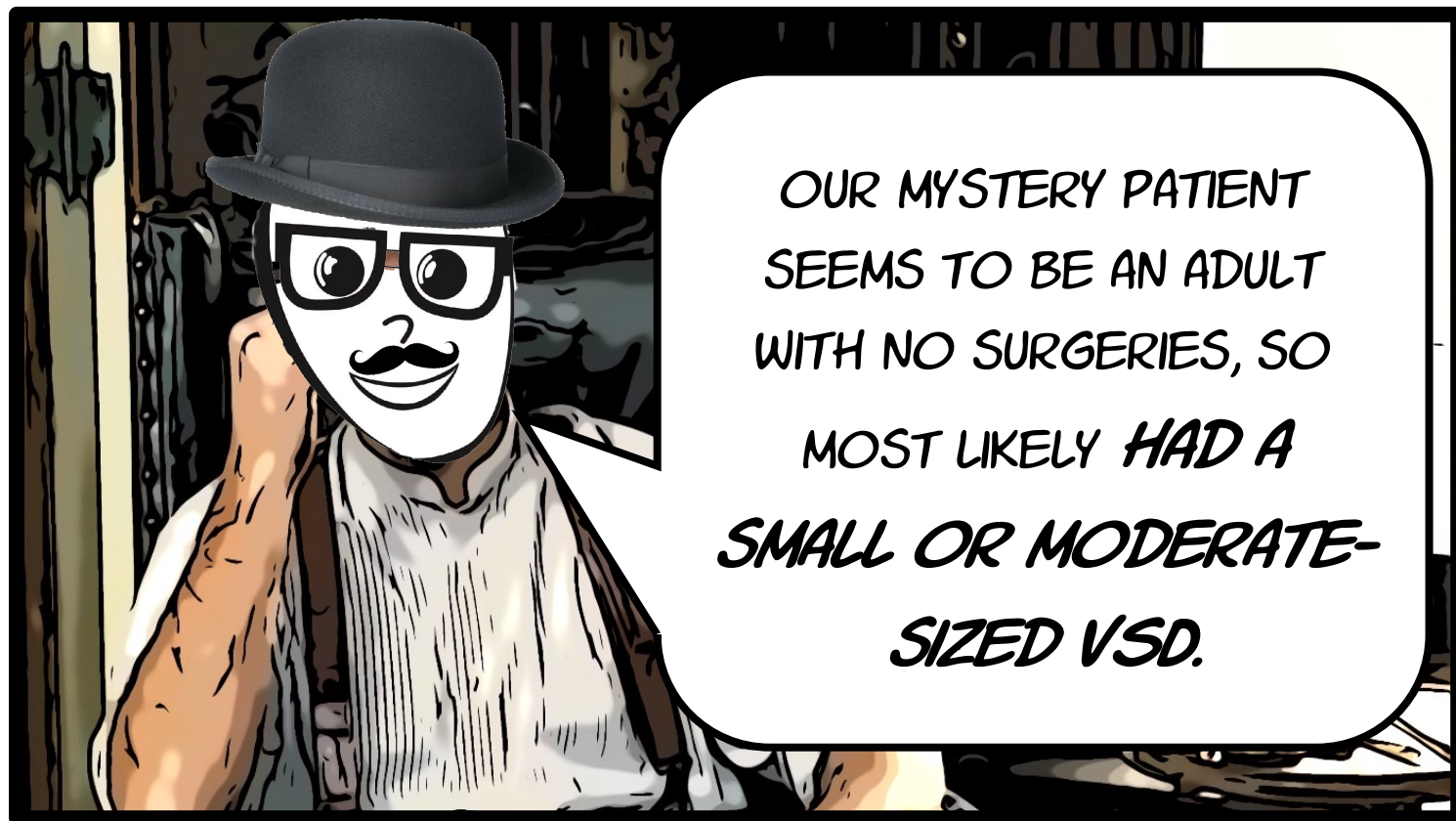


CLINICAL PICTURE OF VSD
DEPENDS ON **SIZE** AND
DOWNSTREAM VASCULAR
RESISTANCE

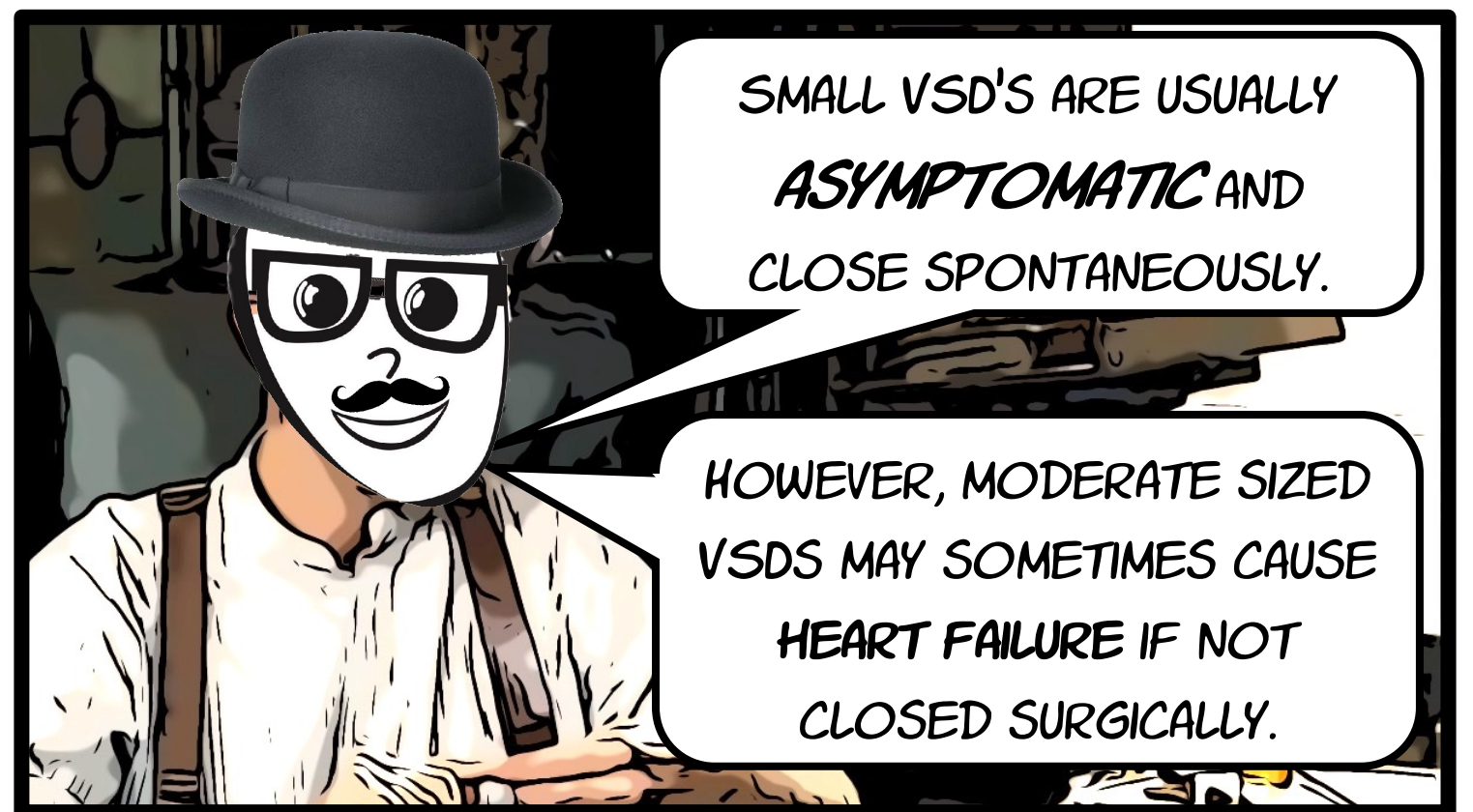
LARGE VSD'S ARE USUALLY
SYMPTOMATIC IN *EARLY*
CHILDHOOD.



No surgical first

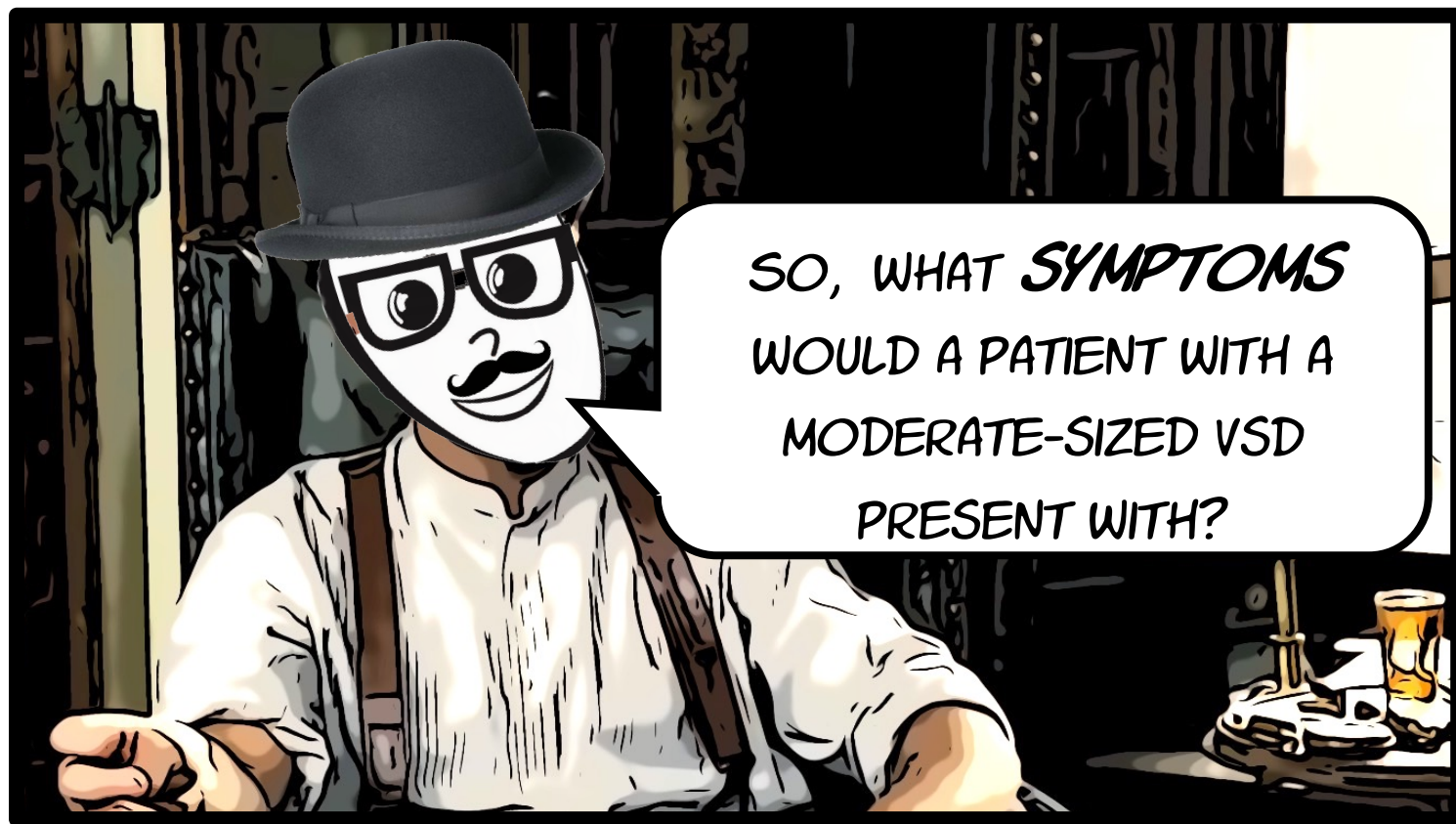


OUR MYSTERY PATIENT
SEEMS TO BE AN ADULT
WITH NO SURGERIES, SO
MOST LIKELY *HAD A*
SMALL OR MODERATE-
SIZED VSD.

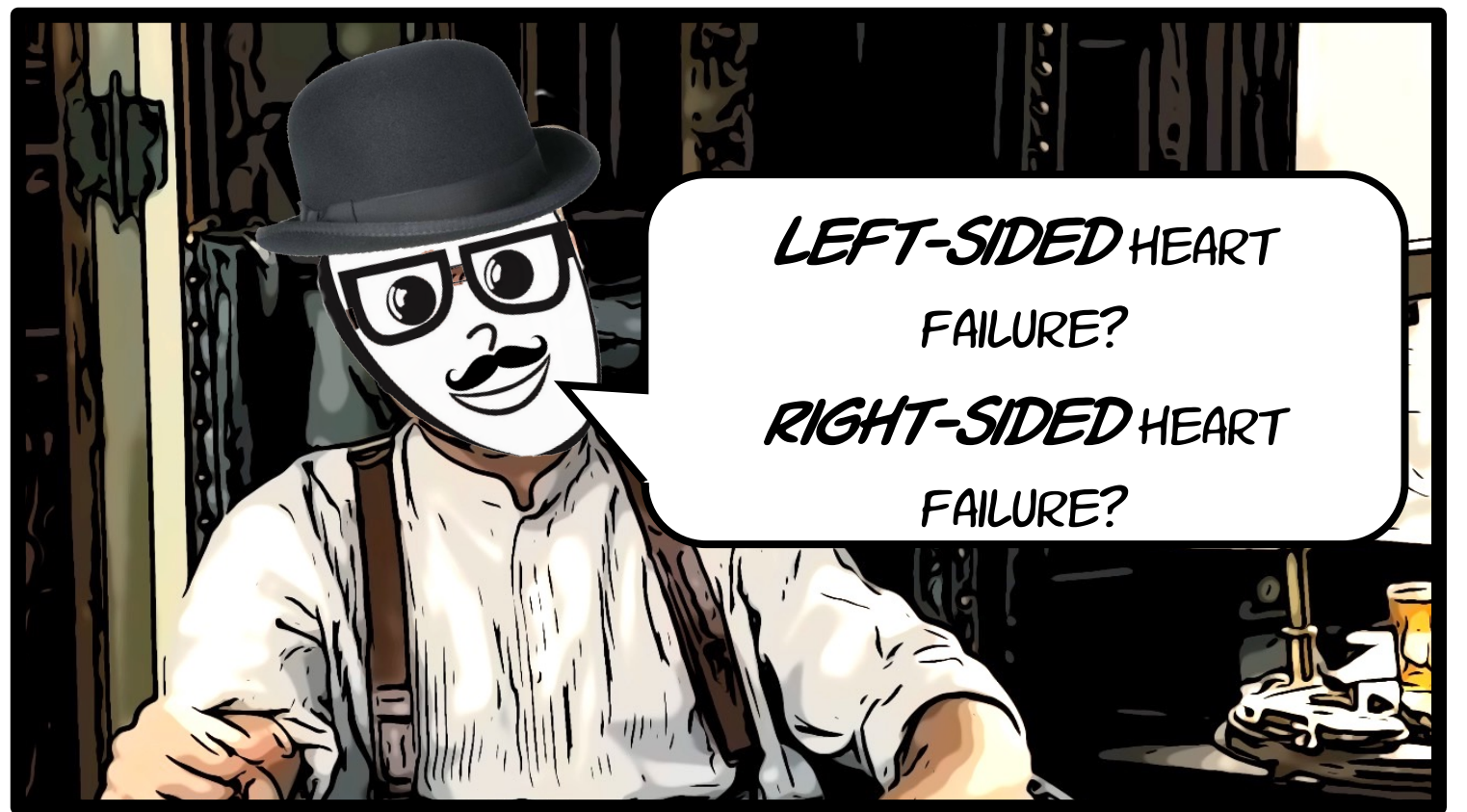


SMALL VSD'S ARE USUALLY
ASYMPTOMATIC AND
CLOSE SPONTANEOUSLY.

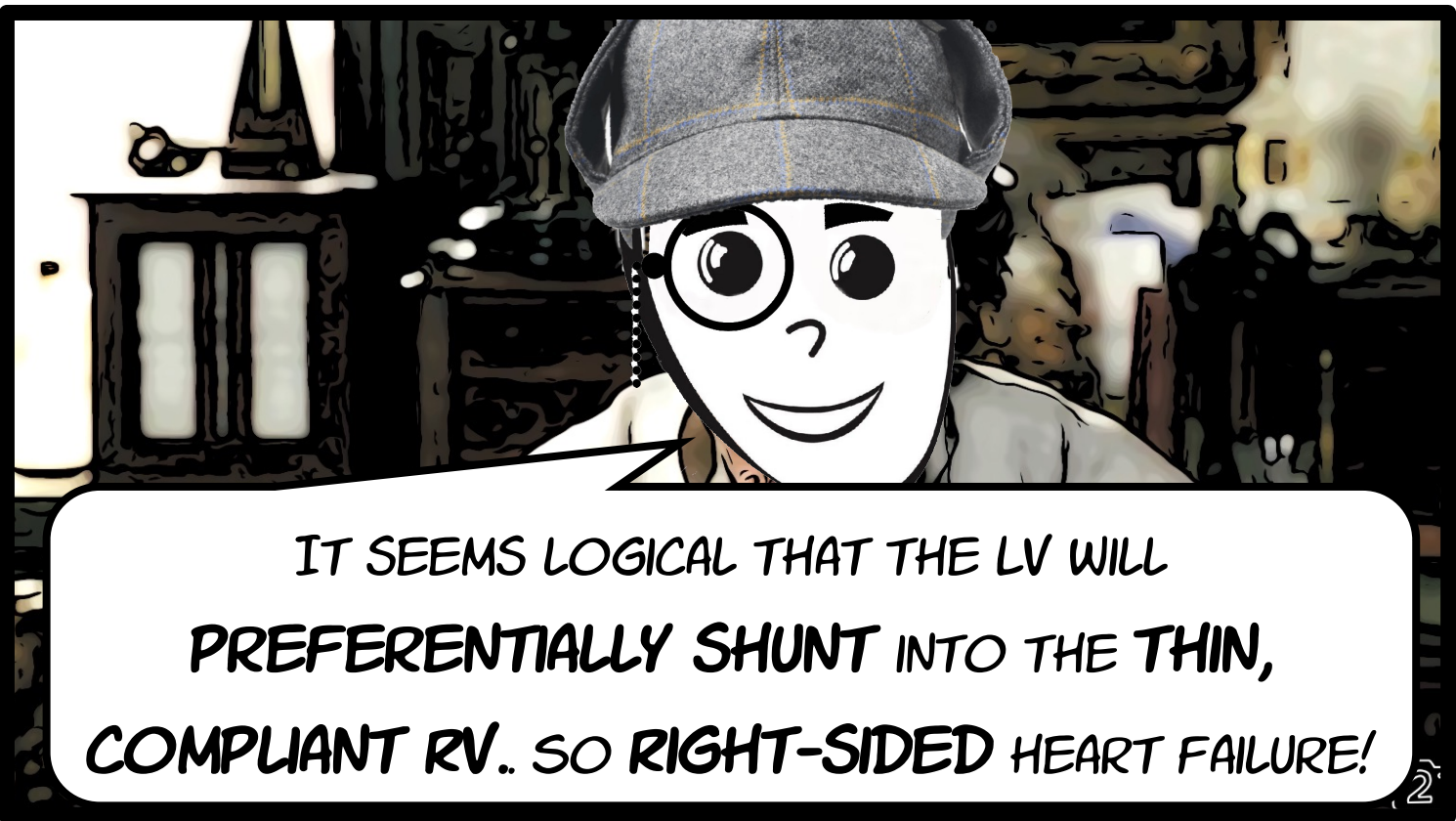
HOWEVER, MODERATE SIZED
VSDS MAY SOMETIMES CAUSE
HEART FAILURE IF NOT
CLOSED SURGICALLY.



SO, WHAT *SYMPTOMS*
WOULD A PATIENT WITH A
MODERATE-SIZED VSD
PRESENT WITH?



LEFT-SIDED HEART
FAILURE?
RIGHT-SIDED HEART
FAILURE?

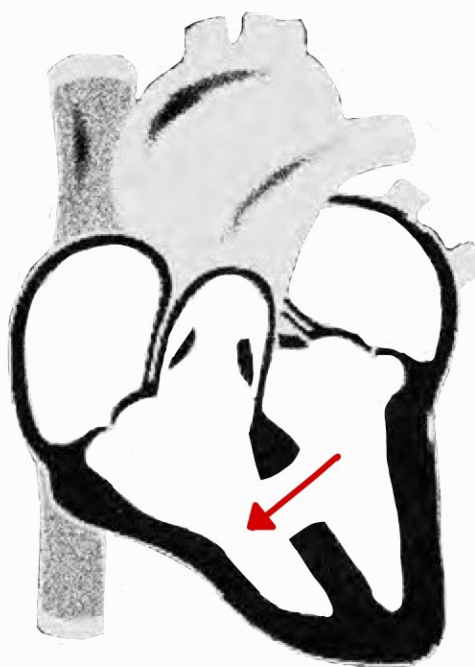


IT SEEMS LOGICAL THAT THE LV WILL
PREFERENTIALLY SHUNT INTO THE THIN,
COMPLIANT RV.. SO *RIGHT-SIDED* HEART FAILURE!

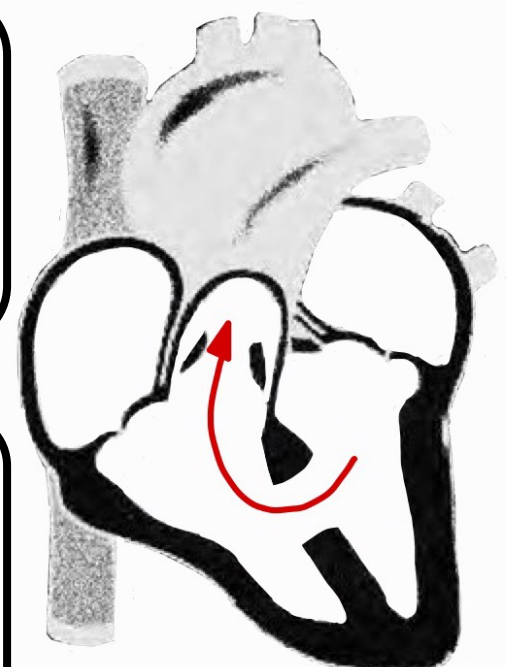


YOU *SEE*, BUT YOU *DO*
NOT OBSERVE
MY DEAR FRIEND!

SHUNTING OCCURS DURING **SYSTOLE**, MEANING THAT BLOOD MOVES FROM THE LV INTO THE **ALREADY CONTRACTING RV** ...



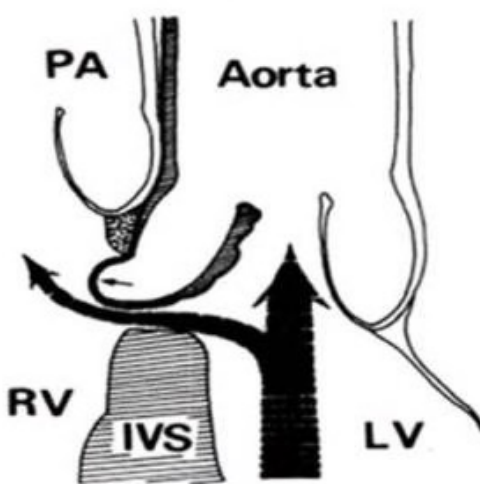
...AND IS MOVED QUICKLY INTO THE PULMONARY ARTERIES, (AND THUS, VSD SHUNTING IS **DEPENDENT ON PULMONARY VASCULAR RESISTANCE!**)



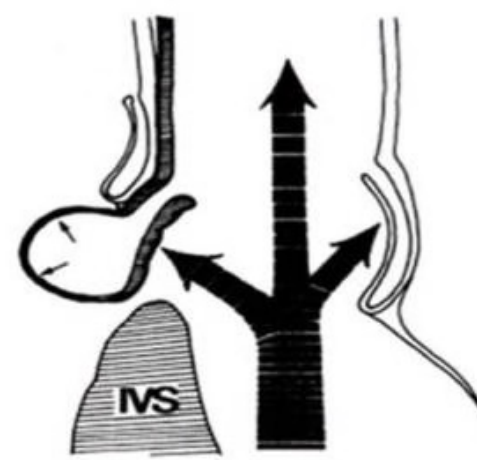
... THEN **BACK TO THE LV**. THIS RESULTS IN SYMPTOMS AND SIGNS OF **LV VOLUME OVERLOAD**.

Hemodynamic Impact of **VSD jet** on aortic valve

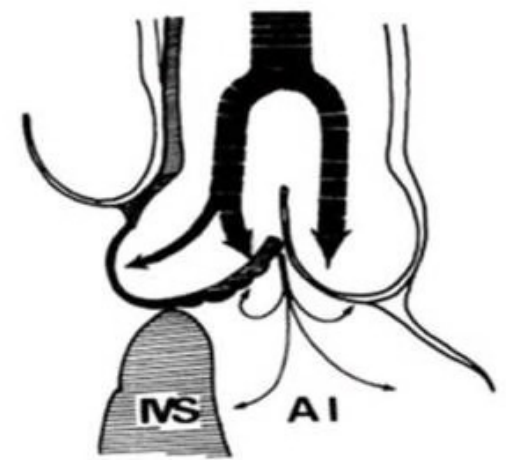
INTERESTINGLY, SOME VSD'S CAN ALSO CAUSE LV DYSFUNCTION BY CAUSING **AORTIC VALVE INSUFFICIENCY**



The lift* (Early systole)

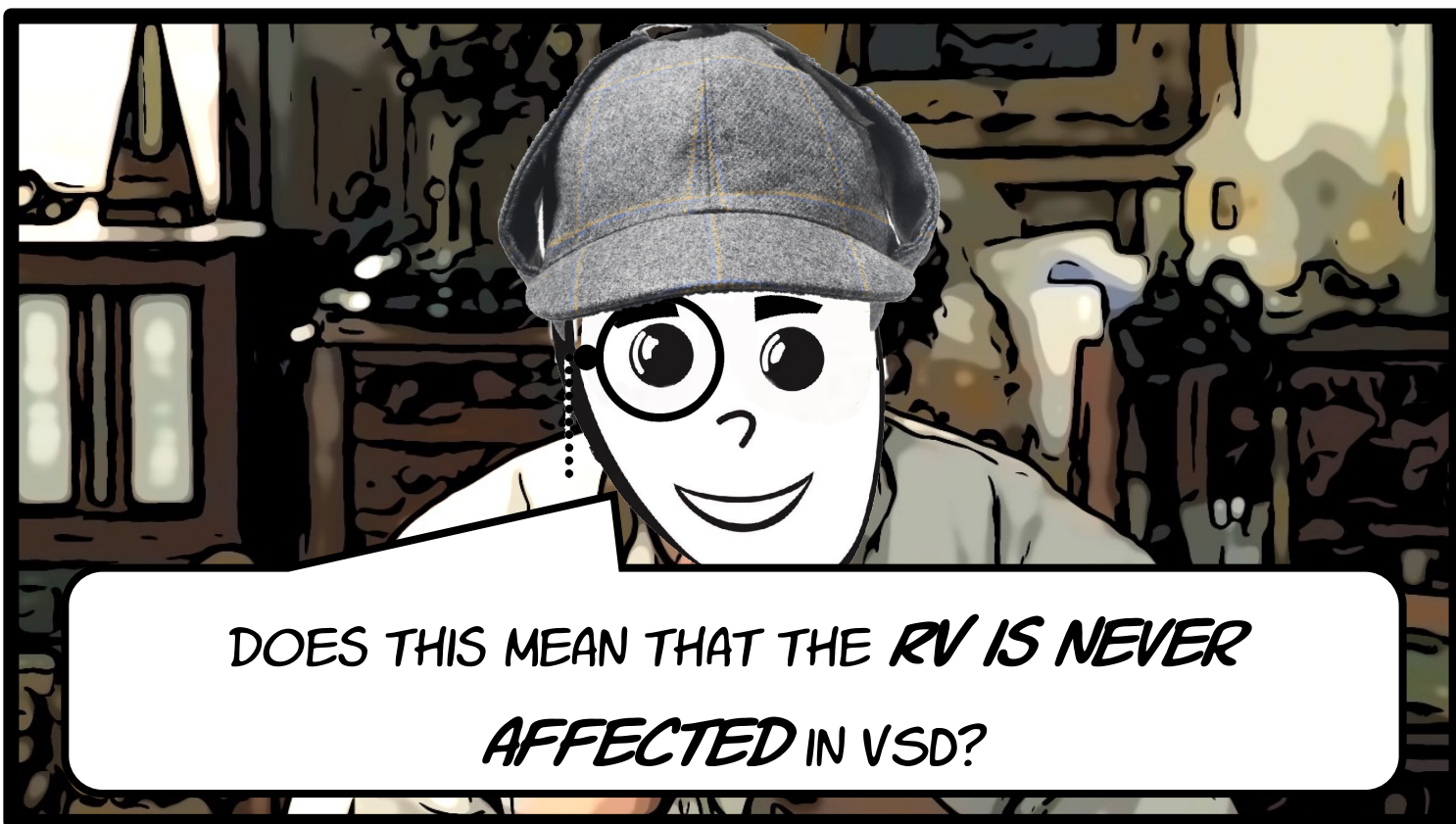


The push** (Mid systole)



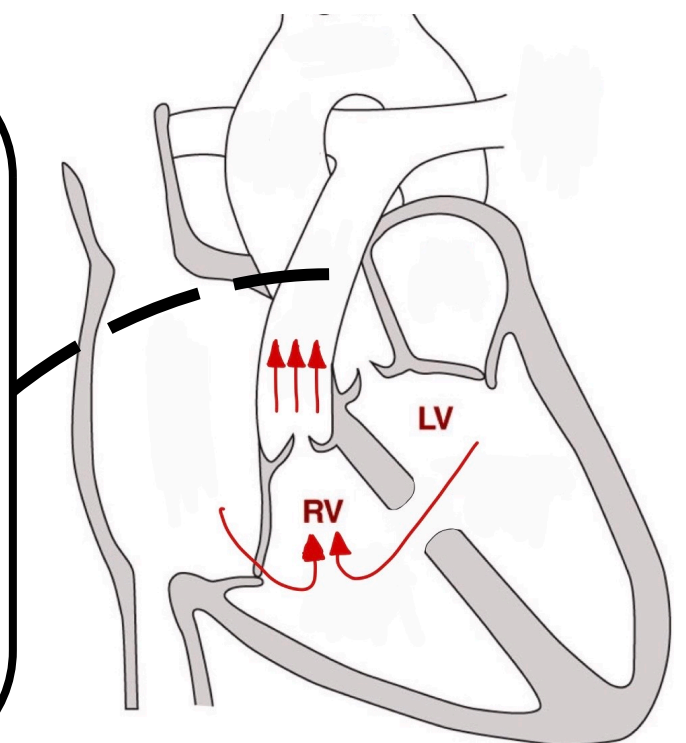
The prolapse*** (Early diastole)

Source: www.Drsvenkatesan.com, modified from Tatsuno et al TATSUNO, K., et al. (1973). "Pathogenetic Mechanisms of Prolapsing Aortic Valve and Aortic Regurgitation Associated With Ventricular Septal Defect." *Circulation* 48(5): 1028-1037.

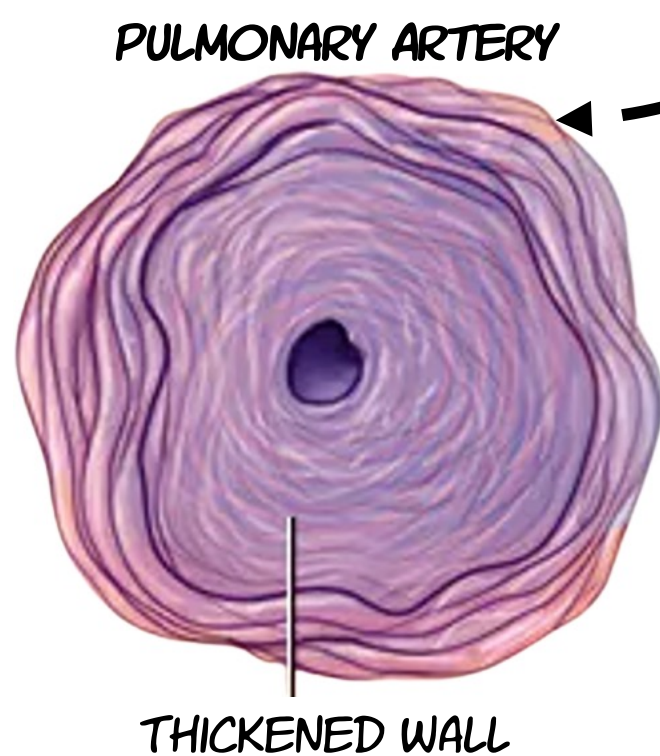


DOES THIS MEAN THAT THE **RV IS NEVER AFFECTED** IN VSD?

INITIALLY, THE INCREASED PULMONARY BLOOD FLOW RESULTS IN **REVERSIBLE VASOCONSTRICTION** AND A RISE IN THE PULMONARY VASCULAR RESISTANCE.

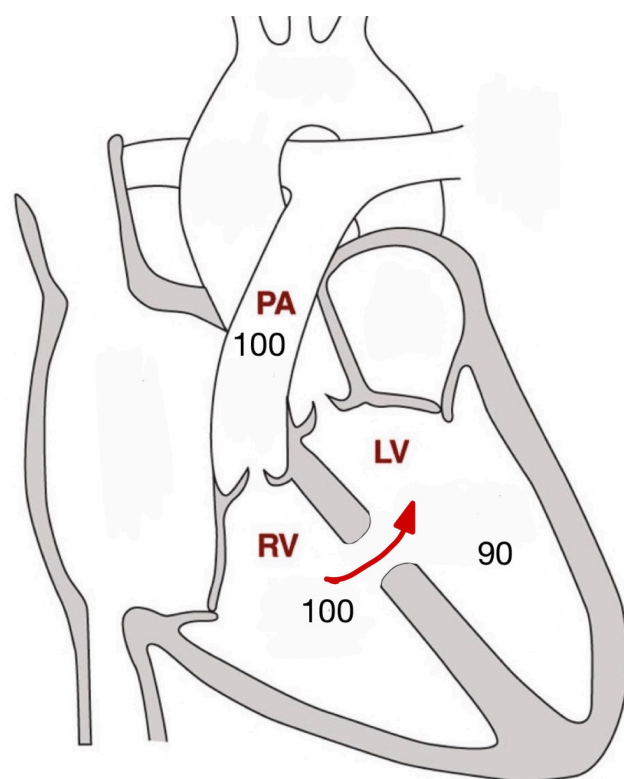


WITH TIME, THIS LEADS TO **HYPERTROPHY** OF THE MEDIAL MUSCLE LAYER OF THE PULMONARY ARTERIOLES AND **IRREVERSIBLE REMODELLING** AND **ELEVATED PULMONARY VASCULAR RESISTANCE** ...



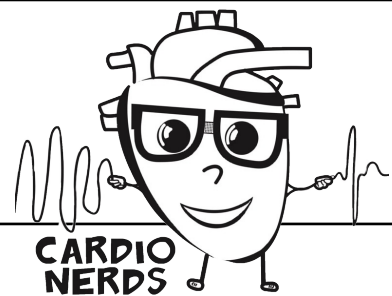
... ULTIMATELY LEADING TO **PULMONARY HYPERTENSION** AND **RV PRESSURE OVERLOAD**.

THE PRESSURES IN THE PULMONARY ARTERY AND RV **CONTINUE TO RISE** OVER TIME. WHEN THE PA/RV PRESSURE **EXCEEDS THE SYSTEMIC PRESSURE...**



... THE SHUNT BECOMES **RIGHT-TO-LEFT**. AND THE PATIENT BECOMES **CYANOTIC**. THIS IS KNOWN AS **EISENMENGER SYNDROME**

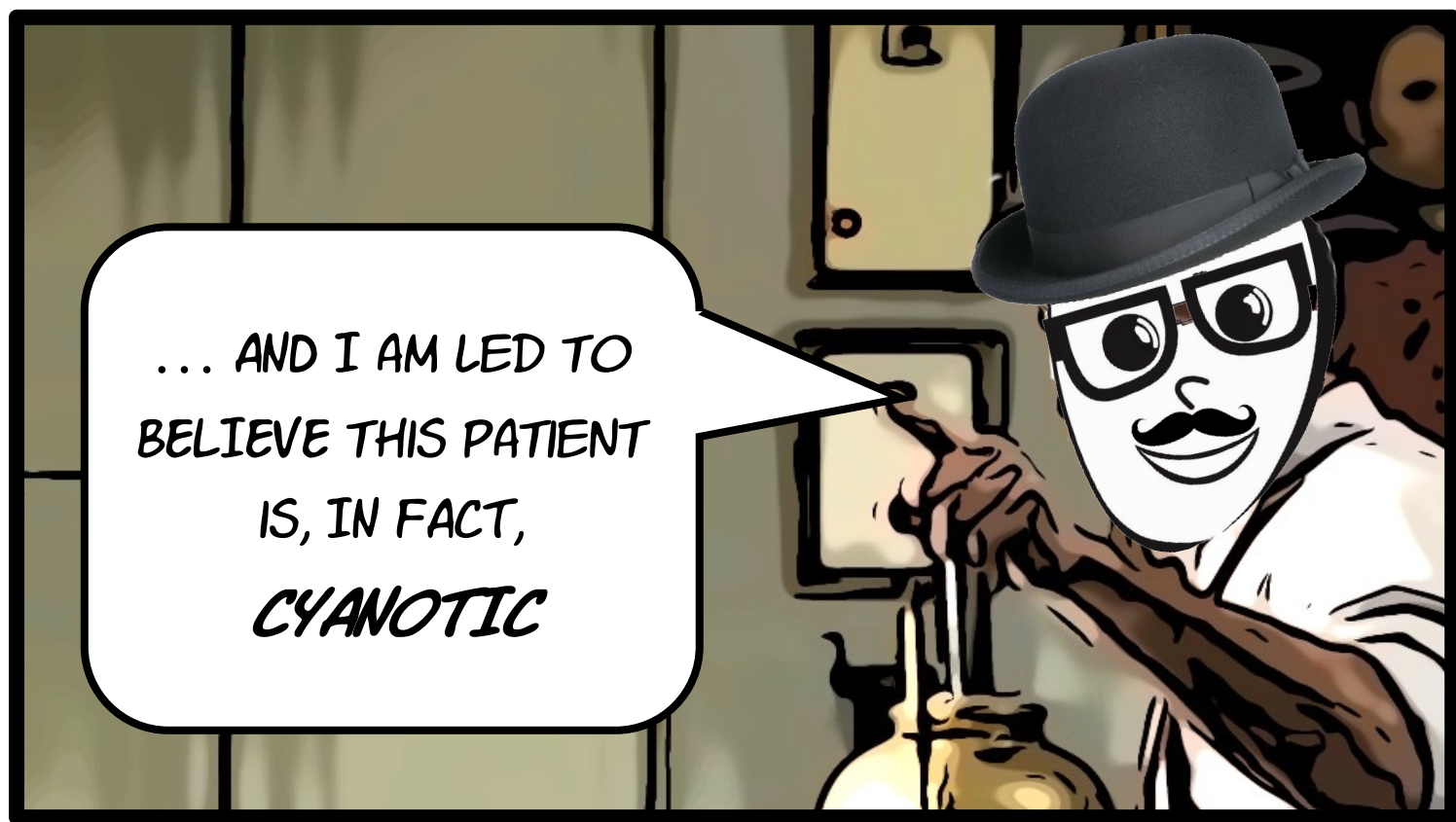
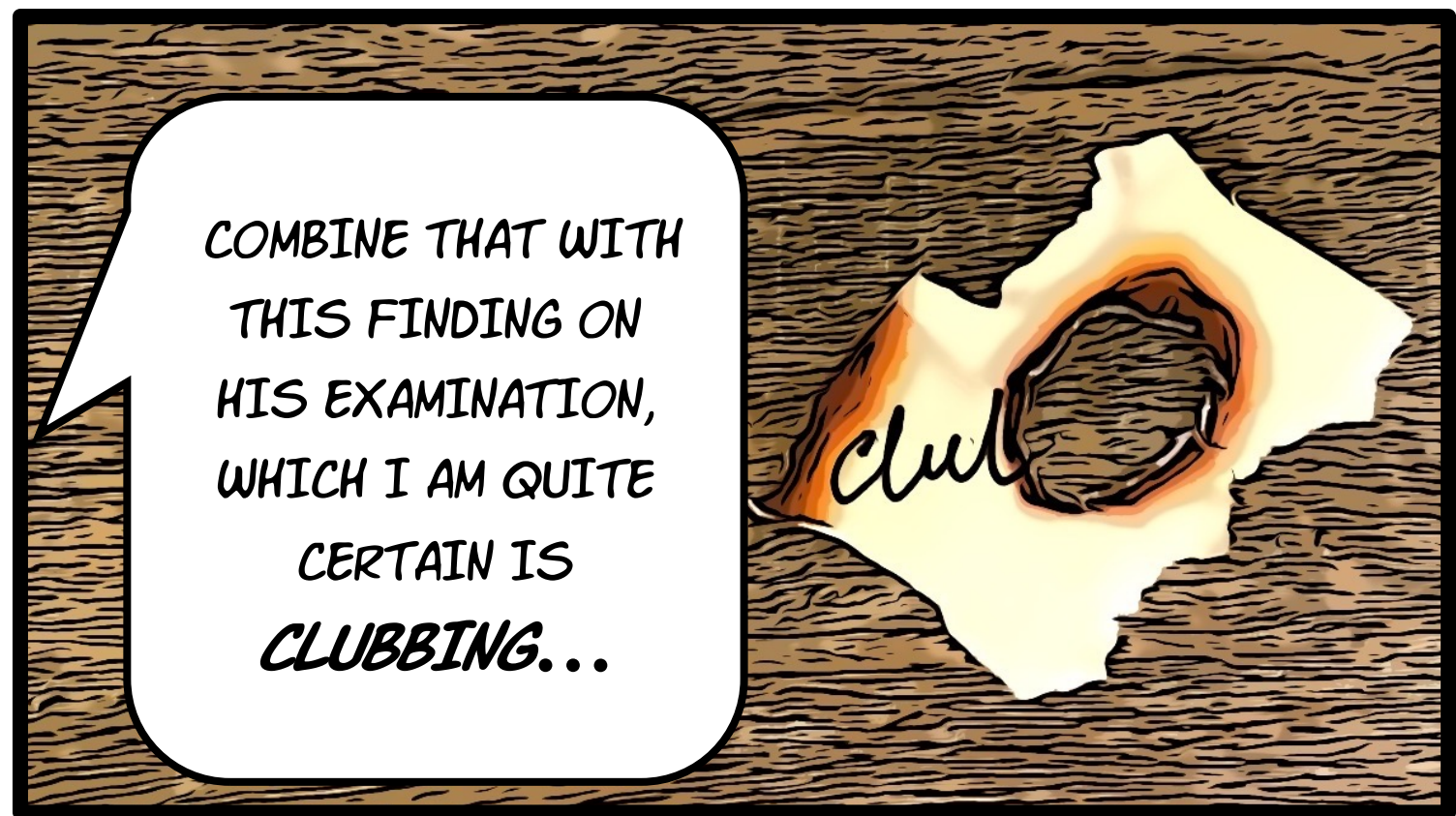
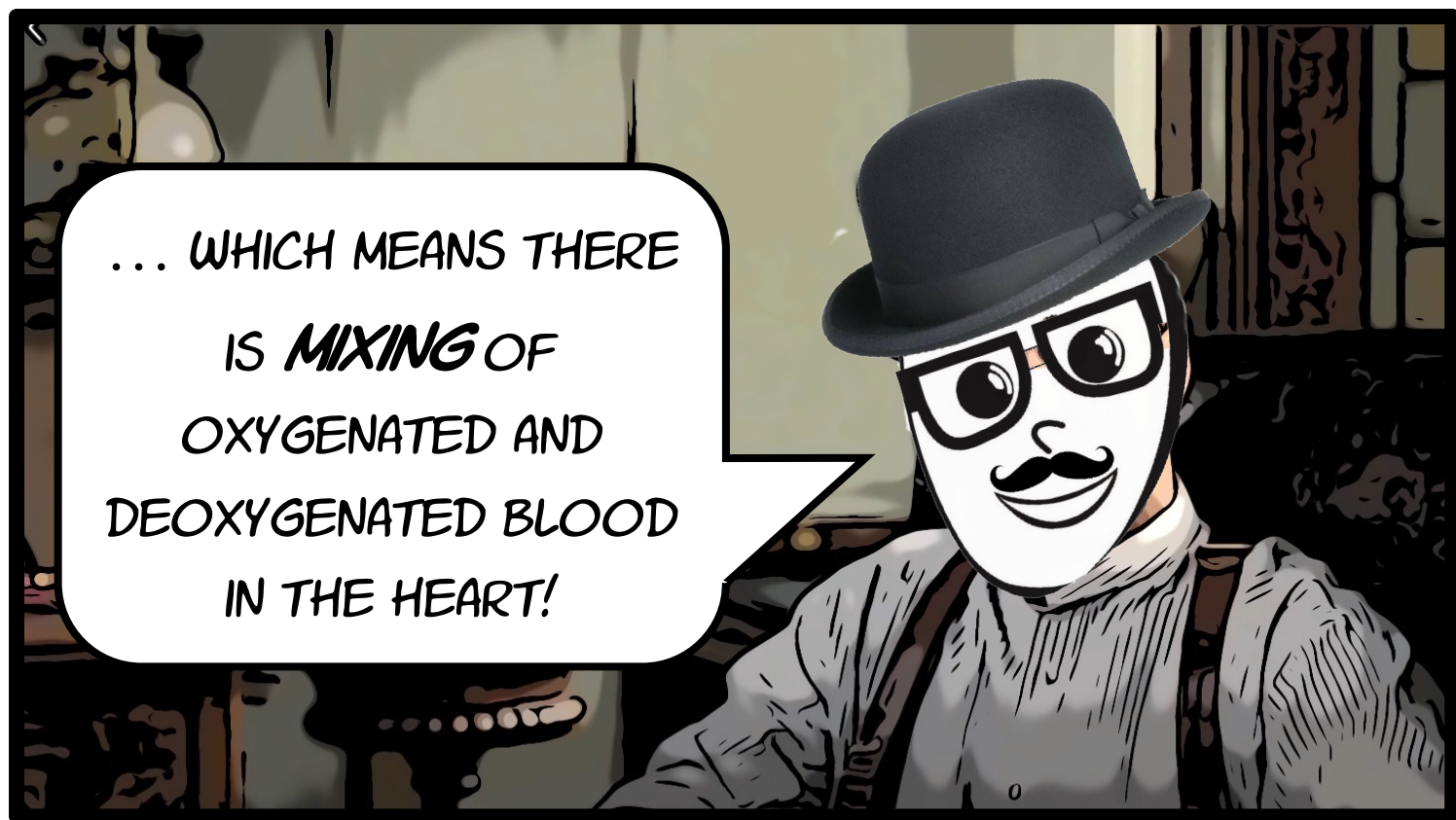
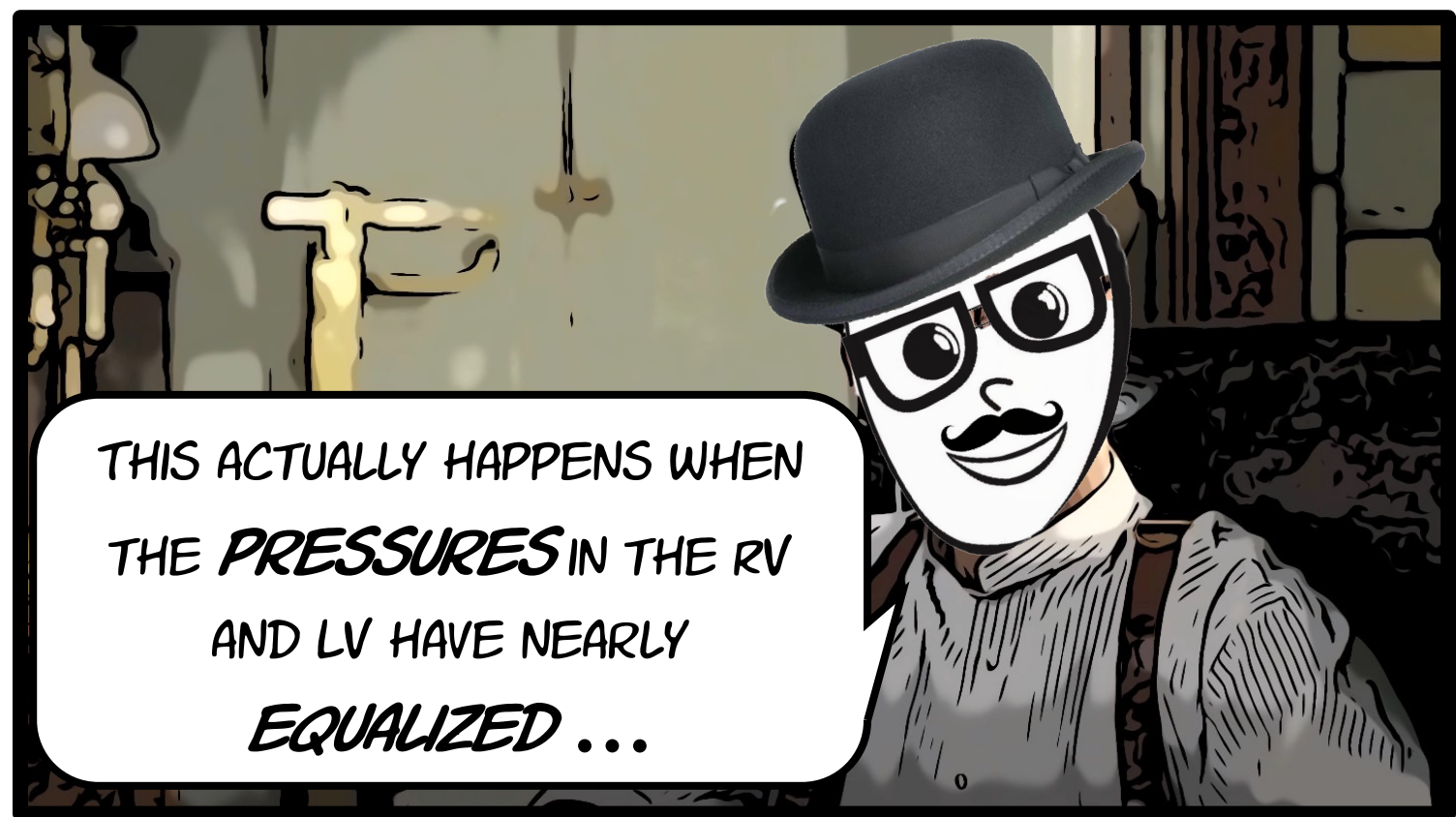
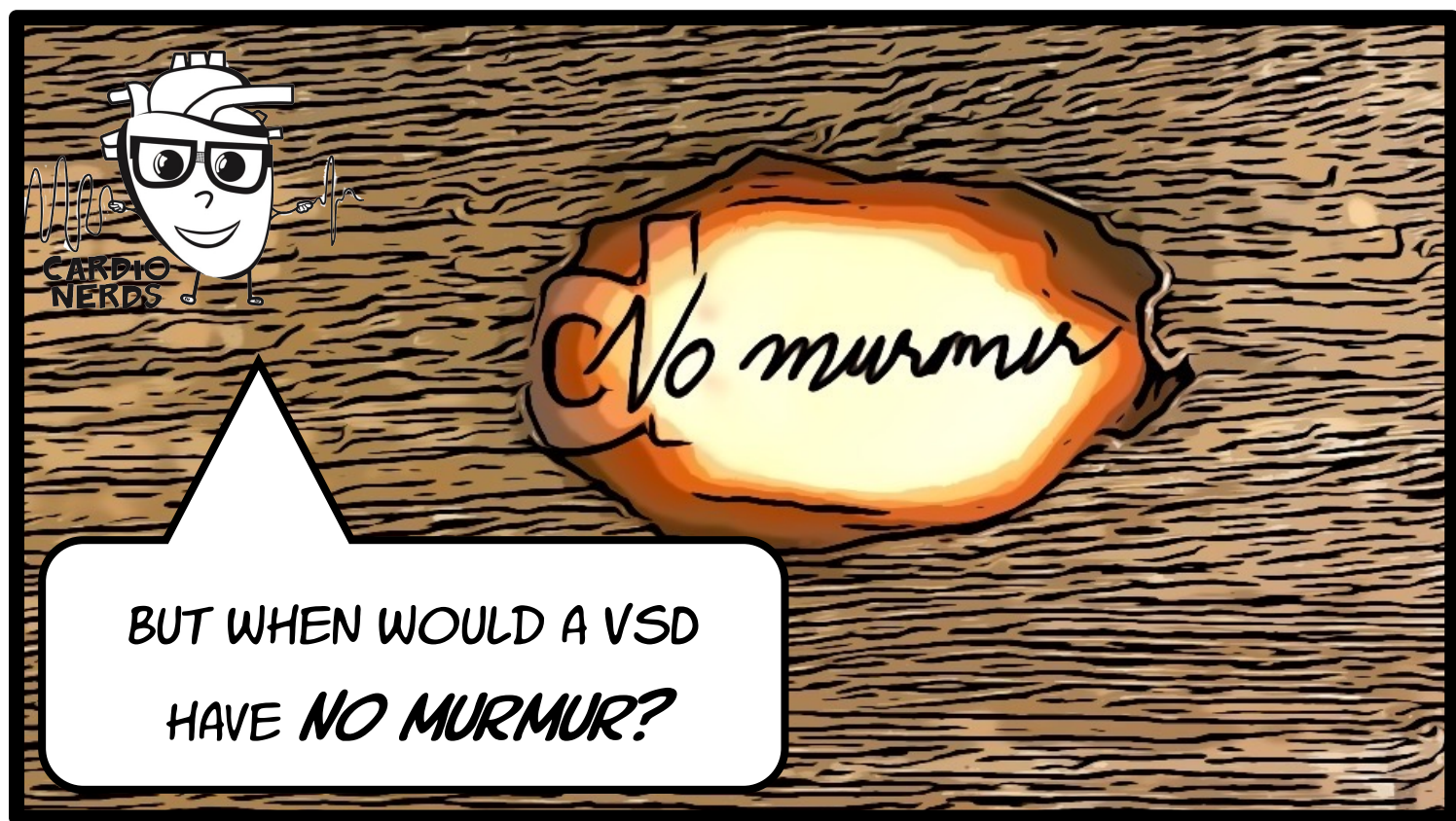
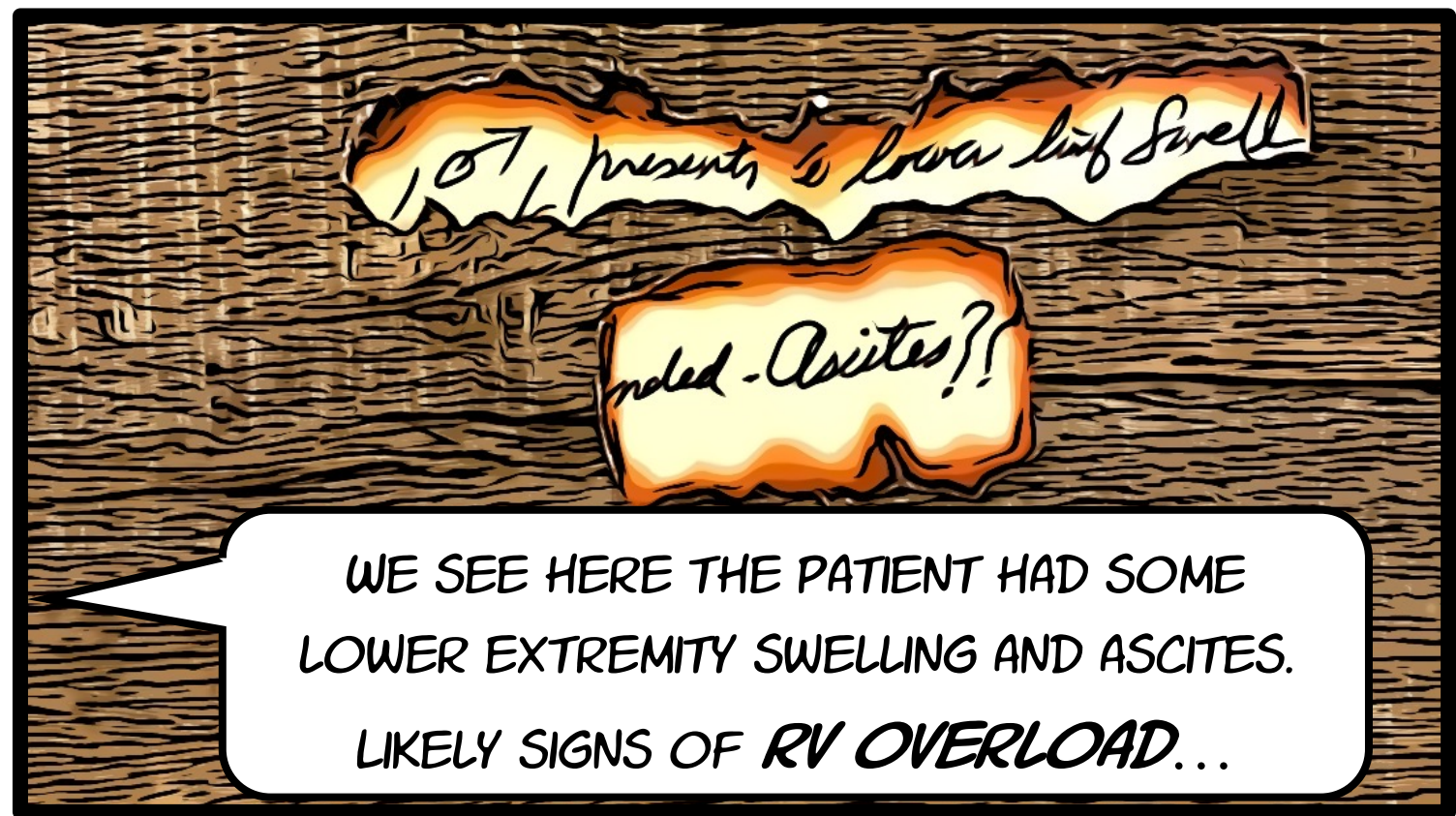
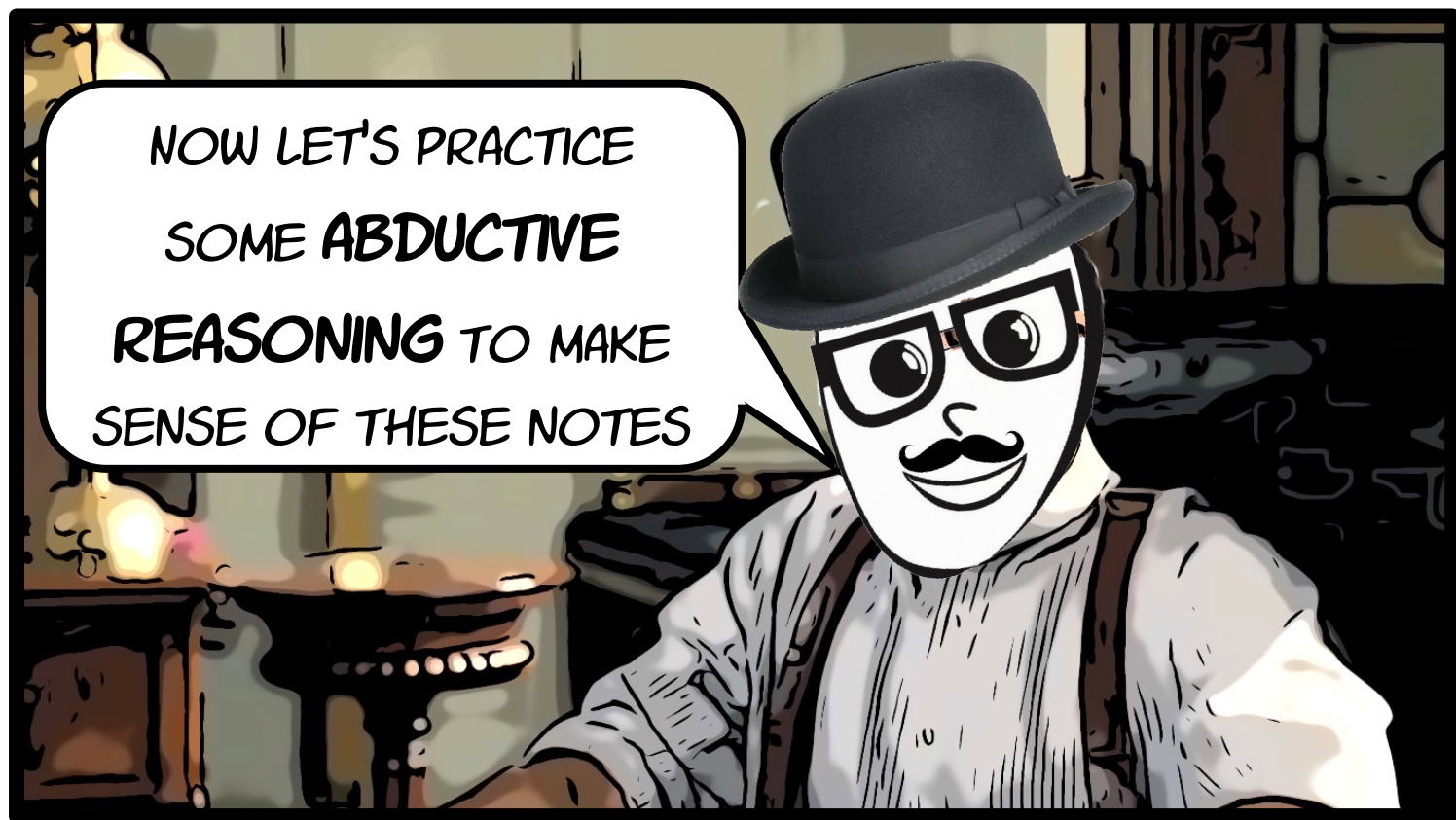
SO, TO SUMMARIZE THE **CLINICAL PICTURE OF ADULTS WITH - A PERSISTENT, ISOLATED - VSD...**

SIZE OF VSD	PULMONARY VASCULAR RESISTANCE	CLINICAL PICTURE
<p><u>SMALL (RESTRICTIVE)</u></p> <ul style="list-style-type: none"> - DIMENSION <25% OF AORTIC ANNULUS DIAMETER. - SHUNT RATIO [QP:QS] < 1.5 : 1 	LOW	 <ul style="list-style-type: none"> • <u>LEFT TO RIGHT SHUNT</u> • USUALLY, <u>ASYMPTOMATIC</u> • LOW RISK OF COMPLICATIONS *
<p><u>MODERATE (MODERATELY RESTRICTIVE)</u></p> <ul style="list-style-type: none"> - DIMENSION 25% - <75% OF AORTIC ANNULUS DIAMETER) - [QP:QS] ≥ 1.5 : 1 AND < 2.1 	MILDLY ELEVATED	<ul style="list-style-type: none"> • <u>LEFT TO RIGHT SHUNT</u> • MAY HAVE ASSOCIATED SYMPTOMS RELATED TO THE <u>LV VOLUME OVERLOAD</u>. • HIGHER RISK OF COMPLICATIONS
<p>OR</p> <p><u>LARGE (NON-RESTRICTIVE)</u></p> <p>**</p> <ul style="list-style-type: none"> - DIMENSION >75% OF AORTIC ANNULUS DIAMETER) - [QP:QS] > 2.1 	PROGRESSIVE	<ul style="list-style-type: none"> • <u>LEFT TO RIGHT SHUNT</u> • MAY ALSO HAVE SYMPTOMS OF <u>RV PRESSURE OVERLOAD</u> DUE TO PROGRESSIVE PULMONARY HYPERTENSION. • HIGHER RISK OF COMPLICATIONS.
	SEVERE (RV PRESSURE EQUALIZES - AND CAN EXCEED - LV/SYSTEMIC PRESSURE)	<ul style="list-style-type: none"> • <u>RIGHT TO LEFT SHUNT (EISENMENGER SYNDROME)</u> • HYPOXEMIA AND CENTRAL <u>CYANOSIS</u>

• COMPLICATIONS INCLUDE ENDOCARDITIS, THROMBO-EMBOLIC COMPLICATIONS, DOUBLE-CHAMBERED RIGHT VENTRICLE (DCRV), OR AORTIC REGURGITATION (AR).

** PATIENTS WITH LARGE VSD'S USUALLY PRESENT DURING EARLY CHILDHOOD WITH SEVERE CONGESTIVE HEART FAILURE.





VSD with Eisenmenger Syndrome!

YOU ARE LOOKING FOR A MAN WITH **BLuish** DISCOLORATION OF HIS SKIN, LEG SWELLING AND CLUBBING OF HIS FINGERS!!

YOU ARE **BRILLIANT!**. I JUST **MIGHT** TAKE YOUR OPINIONS SERIOUSLY IN THE FUTURE!



I NOW KNOW WHO WE SHOULD **INTERROGATE** NEXT!

COME MY FRIEND...

... THE GAME IS AFOOT!

THE END