A Double-Dog-Dare-You Shocking Report: Results of Dual-Sequential Defibrillation Cases

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Question

- What is the optimal electrical therapy for refractory ventricular fibrillation?

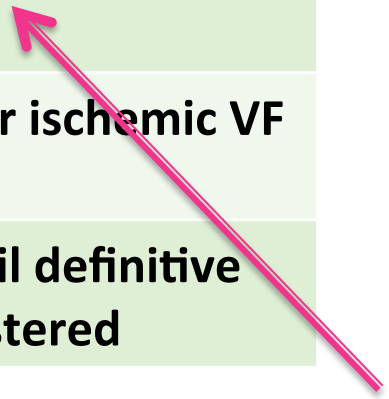
Double Sequential External Defibrillation Definition of Refractory VF

- **Refractory** VF /VTACH
  - Rhythm NEVER converted with defibrillation
  - Example : VF, VF, VF, VF

- **Recurrent** VF / VTACH
  - Rhythm converted successfully with defibrillation but recurred
  - Example : VF, PEA, VF, Asystole, VF

Strategies In Treatment of Refractory Ventricular Fibrillation

Strategies	Effect
High performance + vasopressors CPR	Optimize coronary blood flow
Anti-arrhythmics	Decrease irritability of myocardium
Defibrillation Strategies	Optimize defibrillation
Fix the ischemia : AKA Coronary catheterization	Definitive treatment for ischemic VF
E-CPR / ECMO	Keeps patient alive until definitive therapy can be administered



What is the published literature on Double Sequential Defibrillation for VF/unstable VT?

Double Sequential Defibrillation: Background

Date	Author	Subject	Conclusion
1986	Chang	Canine	Both healthy and infarcted canine hearts required less total energy to terminate VF and single shocks
1986	Jones	Human	Studied 21 patients volunteering to undergo induced VF in EP lab to single or double sequential defibrillation attempts Double sequential had substantial lower defibrillation threshold, patients with repeatedly failed single shocks at maximal voltage had immediately successful double defibrillation as "rescue method"
1989	Bardy	Human	16 out of hospital cardiac arrest survivors were randomized and demonstrated lower defibrillation thresholds in infarcted hearts as well

Double Sequential Defibrillation: Background

Date	Author	Study	Conclusion
1994	Hoch	2,990 consecutive patients undergoing procedures in EP lab over 3 years.	5 patients with refractory VF with multiple shocks by single defibrillator. All 5 successfully defibrillated on 1st attempt with double sequential and all 5 survived.
2014	Cabanas	Retrospective case series 10 patients with OHCA (6-10 single shocks)	Successful conversion to normal rhythm in 7/10 patients. None survived however.
2014	Gerstein	DSD in IHCA	Successful defibrillation with DSD after 74 minutes of resuscitation
2015	Lybeck	40 yo OHCA after striking against pole playing basket ball	DSD on 8th attempt in ED. CT cardiac contusion to apex and distal lateral wall. Cardiac catheterization revealed normal coronary anatomy. DC with full neurological function.

Proposed Mechanisms of Double Sequential Defibrillation

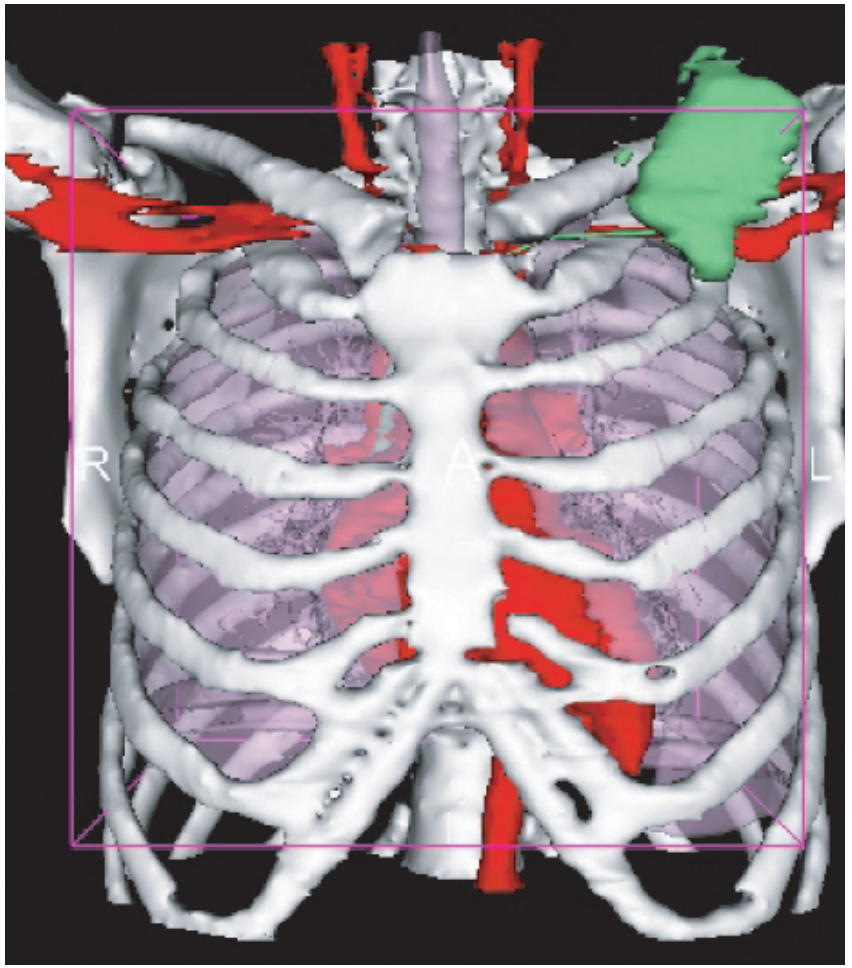
Double and triple sequential shocks reduce ventricular defibrillation threshold in dogs with and without myocardial infarction

A single shock through a pathway including the **interventricular septum** required lower total energy and peak voltage to defibrillate

Chang, J Am Coll Cardiol. 1986 Dec;8(6):1393-405.

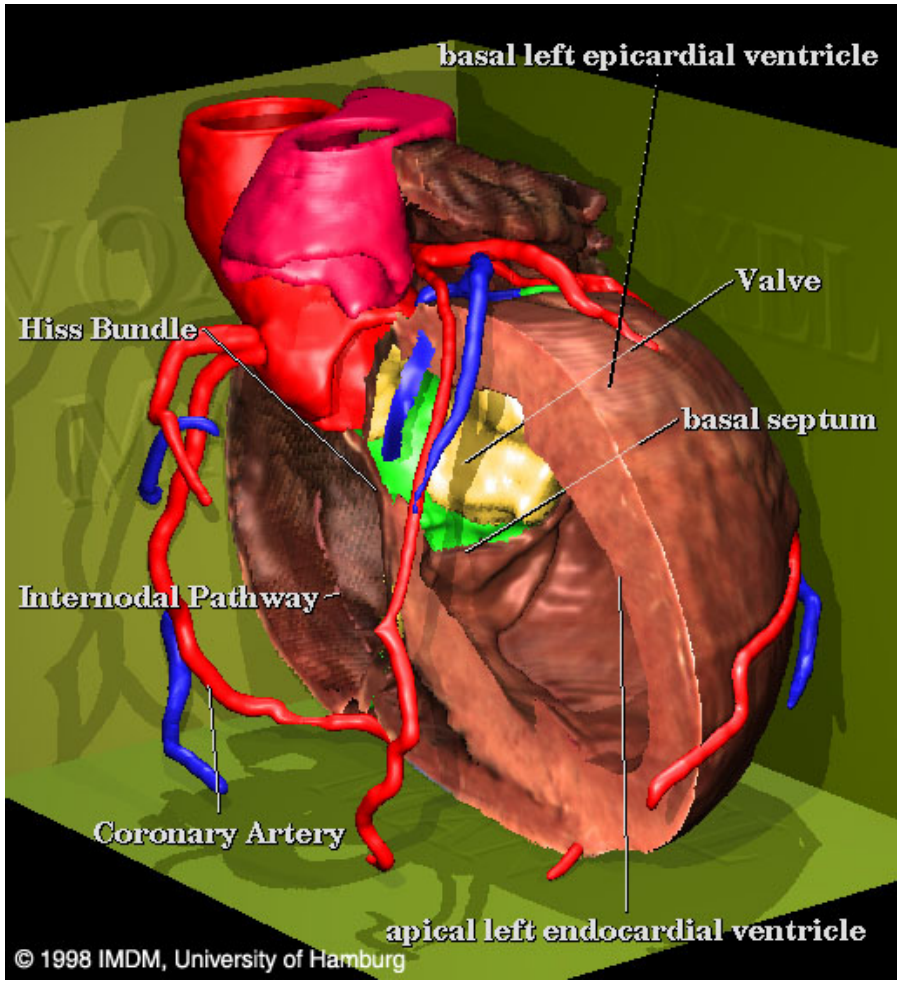
Location of Inter-venticular Septum in the Thorax

- Interventicular Septum
  - AP Defibrillation Pads may provide an advantage



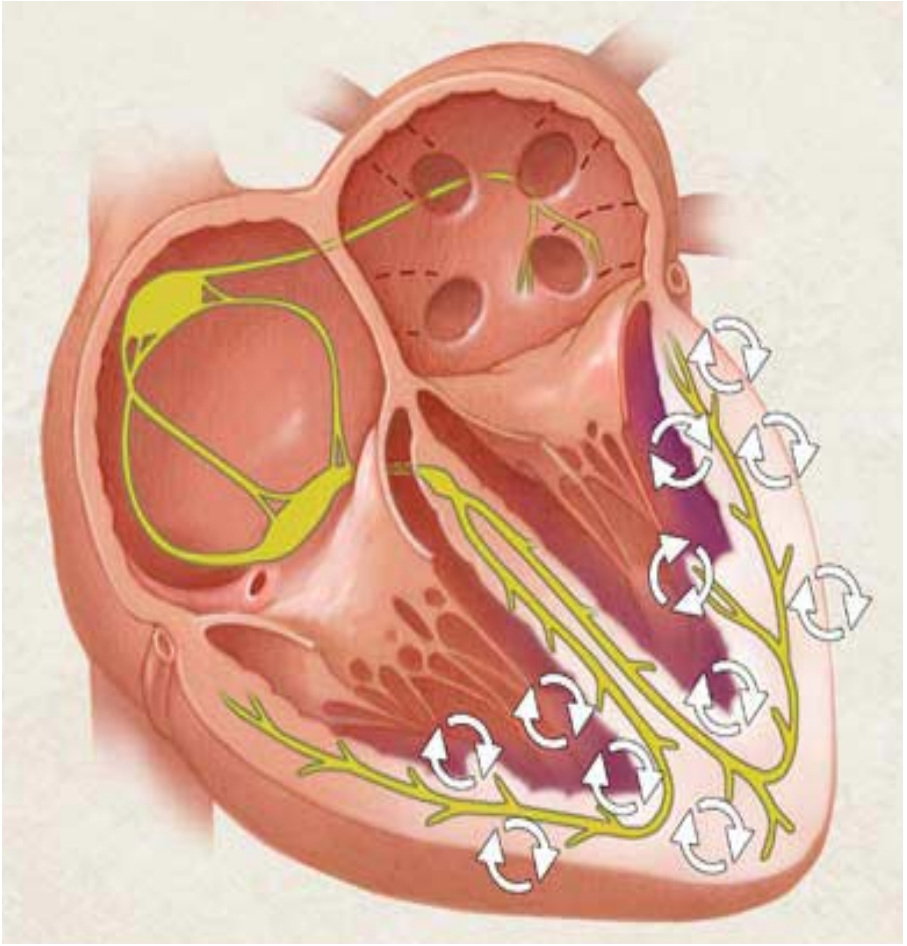
Location of Inter-venticular Septum in the Thorax

- Coverage
  - Sequential pulses may apply a larger current density and more even distribution over the fibrillating myocardium.
  - More cells depolarized
- More Energy



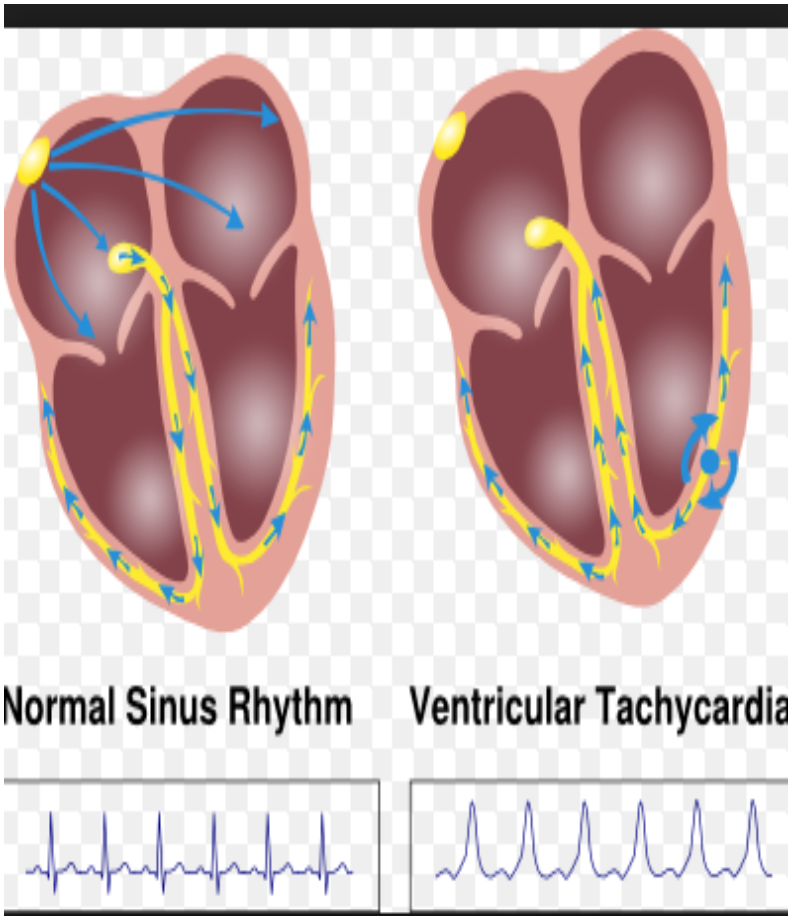
Ventricular Fibrillation / Tachycardia

- Vectors
  - Changing the orientation of electrical vector within the myocardium
  - Initiation two vectors across the myocardium may result in summation vector during the overlap phase between the shocks.



Ventricular Fibrillation / Tachycardia

- Coverage
  - Sequential pulses may apply a larger current density and more even distribution over the fibrillating myocardium.
- Duration of shock
  - Double sequential prolongs shock duration thus depolarizing more myocytes in different electrical phases



Double Sequential External Defibrillation
January 1, 2014 to January 31, 2016

MCEMS Double Sequential Protocol

Refractory to 5 or more shocks

+

Administered 450 mg Amiodarone

+

V- b/pulseless V-tach NEVER converted

Multnomah County EMS : ALS Response

Double Sequential Defibrillation

Double Sequential PAD location

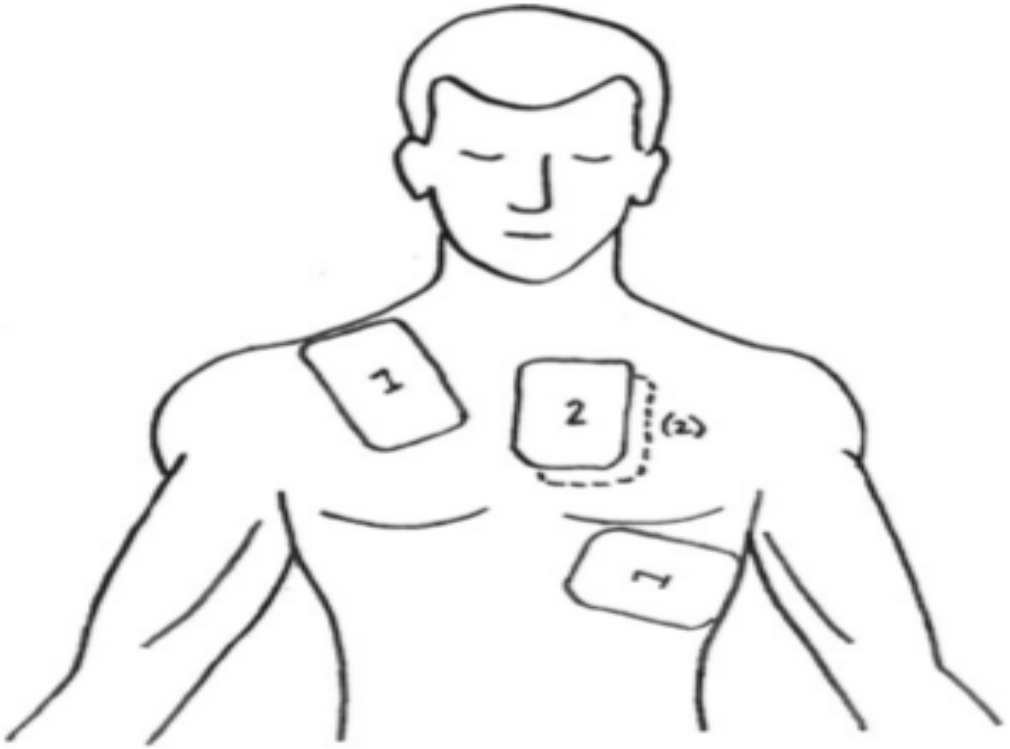
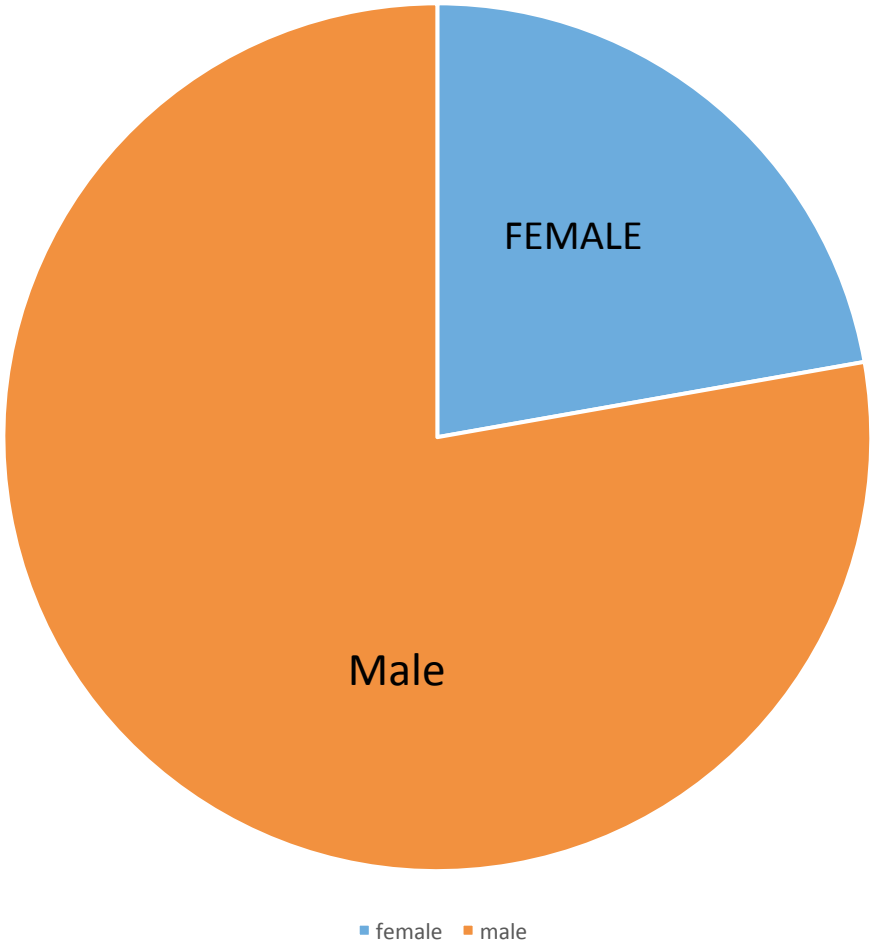
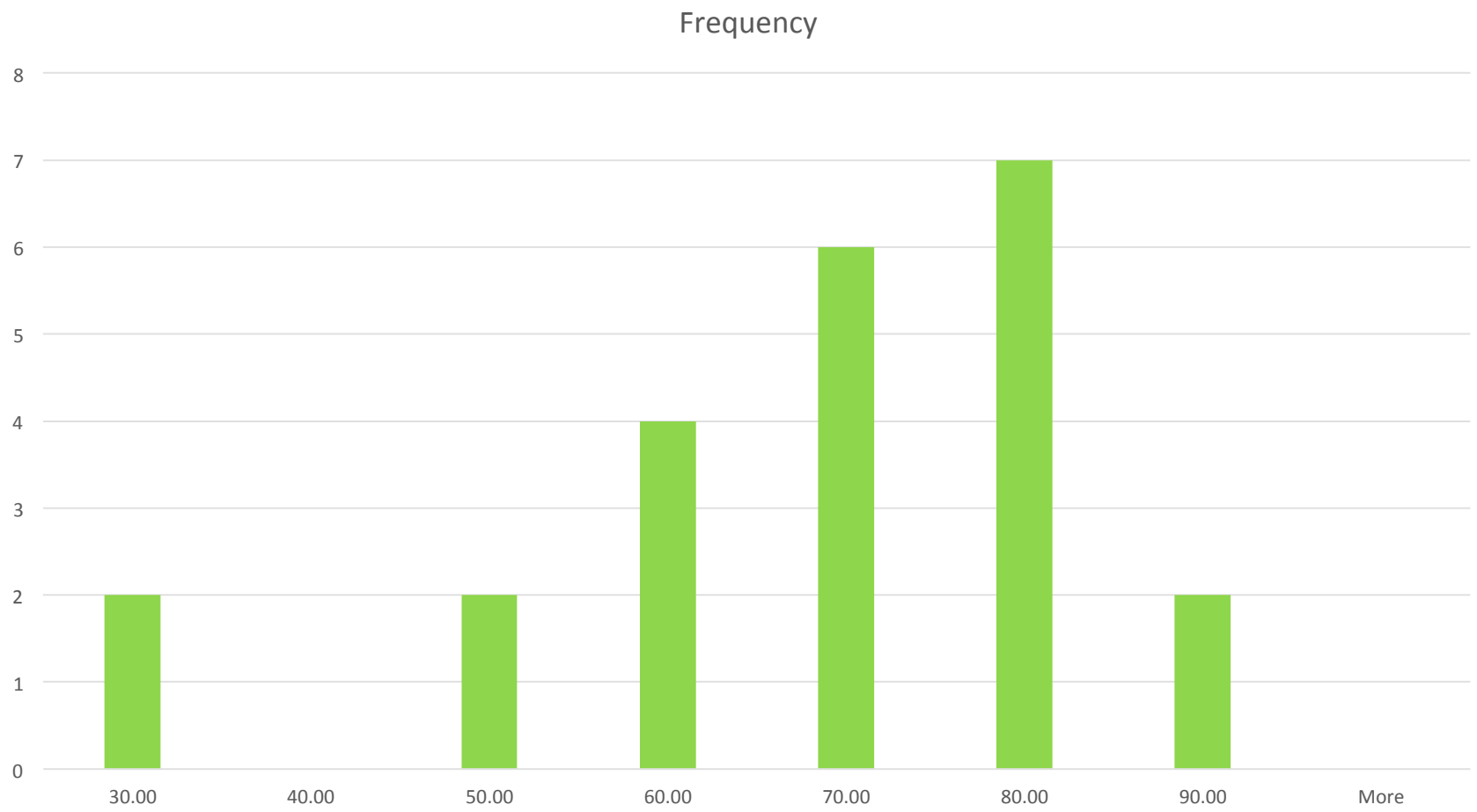


FIGURE 1. Approximate pad placement for anterolateral (1) and anterior–posterior (2) configuration for the successful double sequential defibrillation.

Double Sequential Defibrillation : Sex



Double Sequential Defibrillation: Age



Double Sequential Defibrillation: Outcomes

Outcomes	Number	Percent
Unsuccessful	16	54%
Electrical Success	12	46%
ROSC	9	34%
Total	26	100%

Double Sequential Defibrillation : Electrical Success N=12

Age	Sex	1st Rhythm	ROSC	BP	Comments
54	F	PEA	YES	75 / 56	Success PEA
27	F	VF	YES		Survivor
61	M	PEA			PEA
79	M	Asystole	YES	111 / 76	
71	M	Asystole			VF to PEA, 10 SS, 2 DS to #12 PEA
81	F	VF	YES		Survivor
47	M	VF	YES	106 / 84	Survivor
71	M	VF	YES	84 / 54	
62	F	VF	YES	161 / 128	
29	M	VF			10 total shocks, 6-9 DS, 10 SS successful PEA, efforts terminated in ED
78	M	VF	YES		8 total shocks, #7 DS, #8 SS, PEA with ROSC
75	M	VF	YES	135 / 101	8 total shocks, #8 asystole converting to perfusing rhythm with BP

Double Sequential Defibrillation: ROSC Patients N=9

AGE	SEX	First Known Rhythm	ROSC	Last Known BP	Comments
54	F	PEA	YES	75 / 56	PEA
27	F	VF	YES		Survivor
79	M	Asystole	YES	111 / 76	
81	F	VF	YES		Survivor
47	M	VF	YES	106 / 84	Survivor
71	M	VF	YES	84 / 54	
62	F	VF	YES	161 / 128	
78	M	VF	YES		8 total shocks, #7 DS, #8 SS, PEA with ROSC
75	M	VF	YES	135 / 101	8 total shocks, #8 asystole converting to perfusing rhythm with BP

Double Sequential Survivors N=3

	Initial Rhythm	Defib Sequence	ROSC	Outcome
27 yo F	VF	4 single shocks, 2 DSD, converted on 2nd	Yes	Discharge alive, Cath normal ICD
81 yo F	VF	6 single shocks, 2 DSD converted on 2nd	Yes	DC alive, K = 2.0, normal coronary arteries
47 yo M	VF	6 single shocks, 1 DSD shock converted on 1st shock	Yes	DC alive, non "obstructive CAD"

Double Sequential: Total Shocks Part I

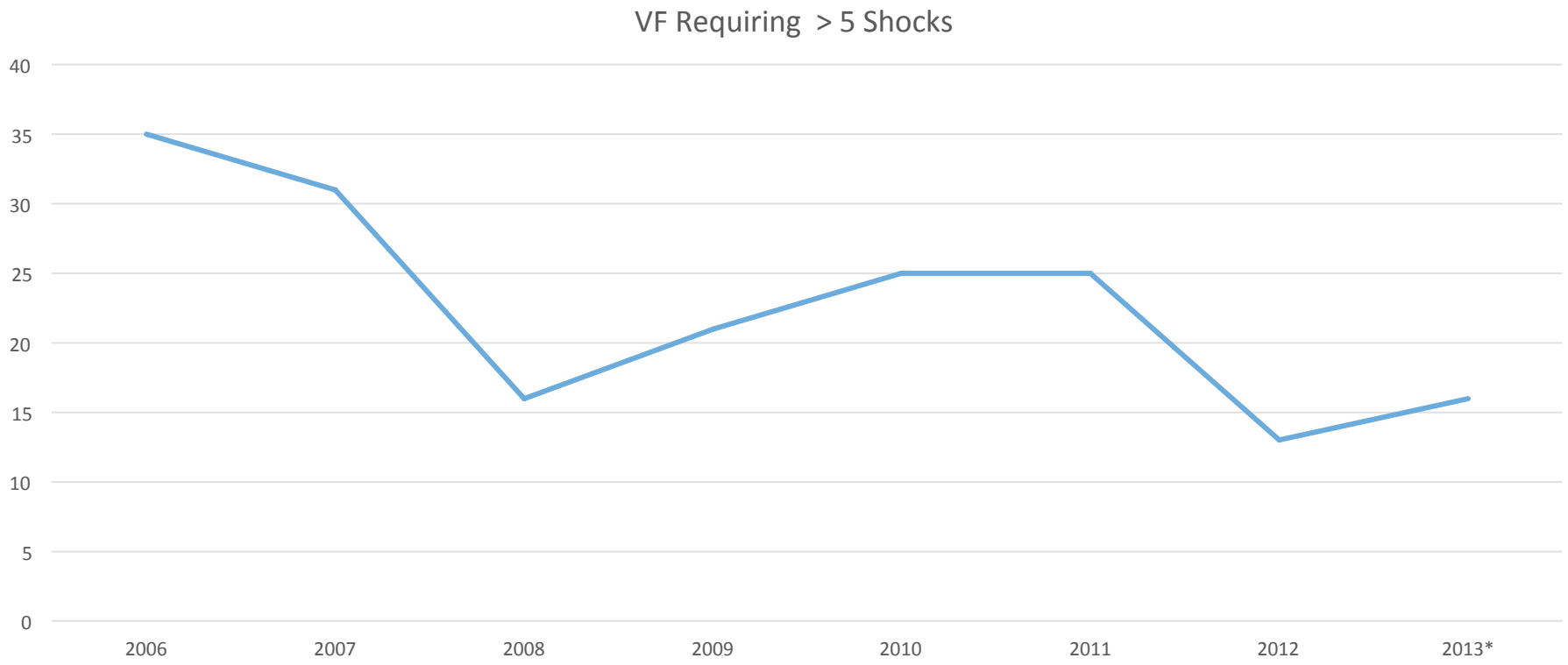
Age	Sex	Total Shocks	DS shocks	Converted on ? DS
54	F	8	6,7,8	3rd DS
67	M	8	7,8	2nd DS
64	M	8	8	No
63	M	9	7,8,9	No
27	F	6	5,6	2nd DS
61	M	7	6,7	2nd DS
79	M	7	6,7	2nd DS
78	M	7	5,6	2nd DS
87	F	6	#6	No
71	M	10	11,12	2nd DS
81	F	8	7,8	2nd DS
67	M	9	8,9	No
63	M	14	9,10,11,12	No
52	M	4	#4	No, brady to asystole

Double Sequential: Total Shocks Part II

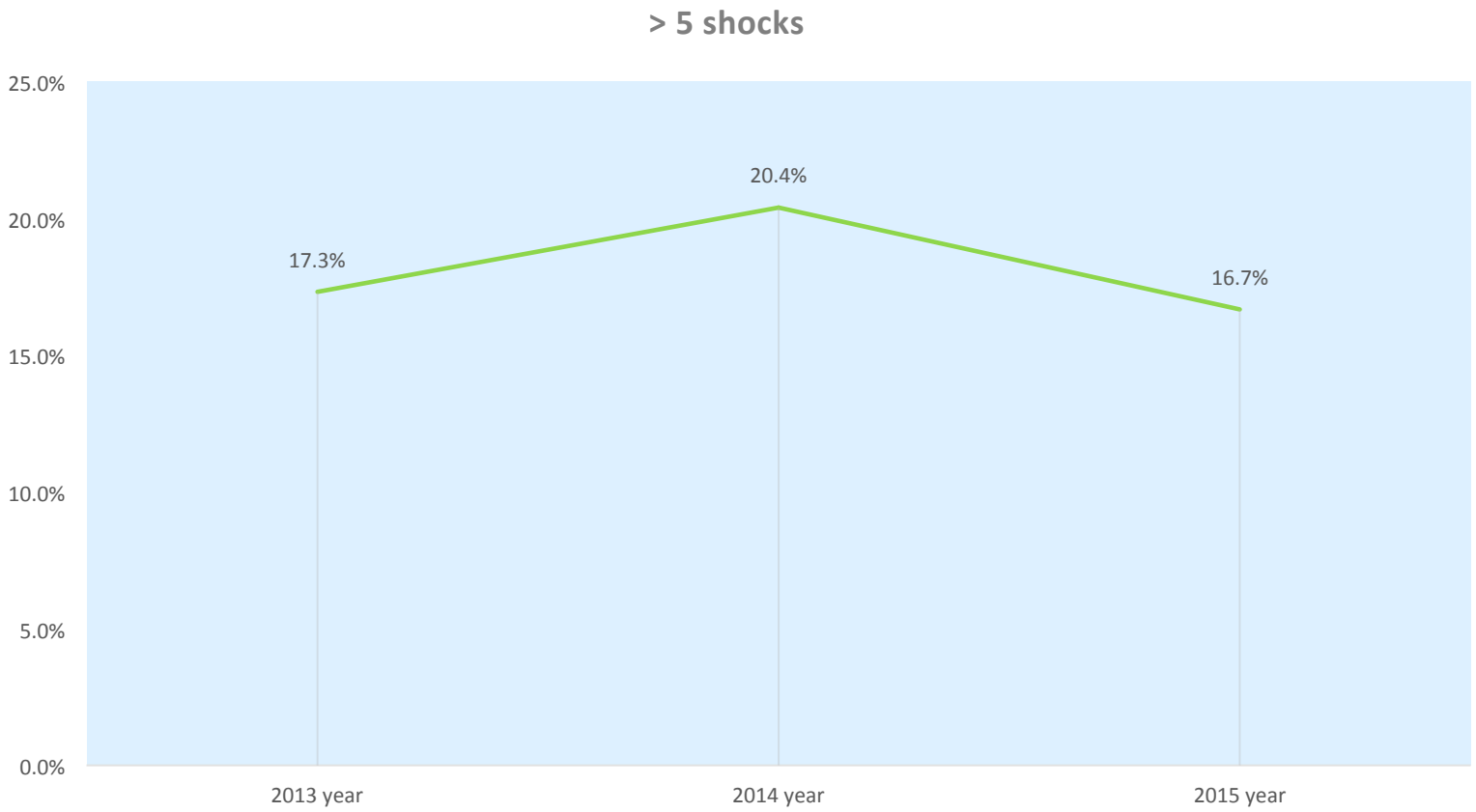
Age	Sex	Total Shocks	DS shocks	Converted on ? DS
79	M	10	6,7,8	No
47	M	7	7	1st
71	M	9	8,9	2nd DS
62	F	4	4	1st DS
29	M	10	6,7,8,9	No, #10 SS successful
72	M	9	8,9	No
58	M	7	4,5,6,7	No
49	M	8	7,8	No
78	M	8	7	#8 SS successful
58	M	9	6,7,8,9	No
71	M	9	7	No
75	M	8	8	1st DS

Does your data show that DSD is better than SSD?

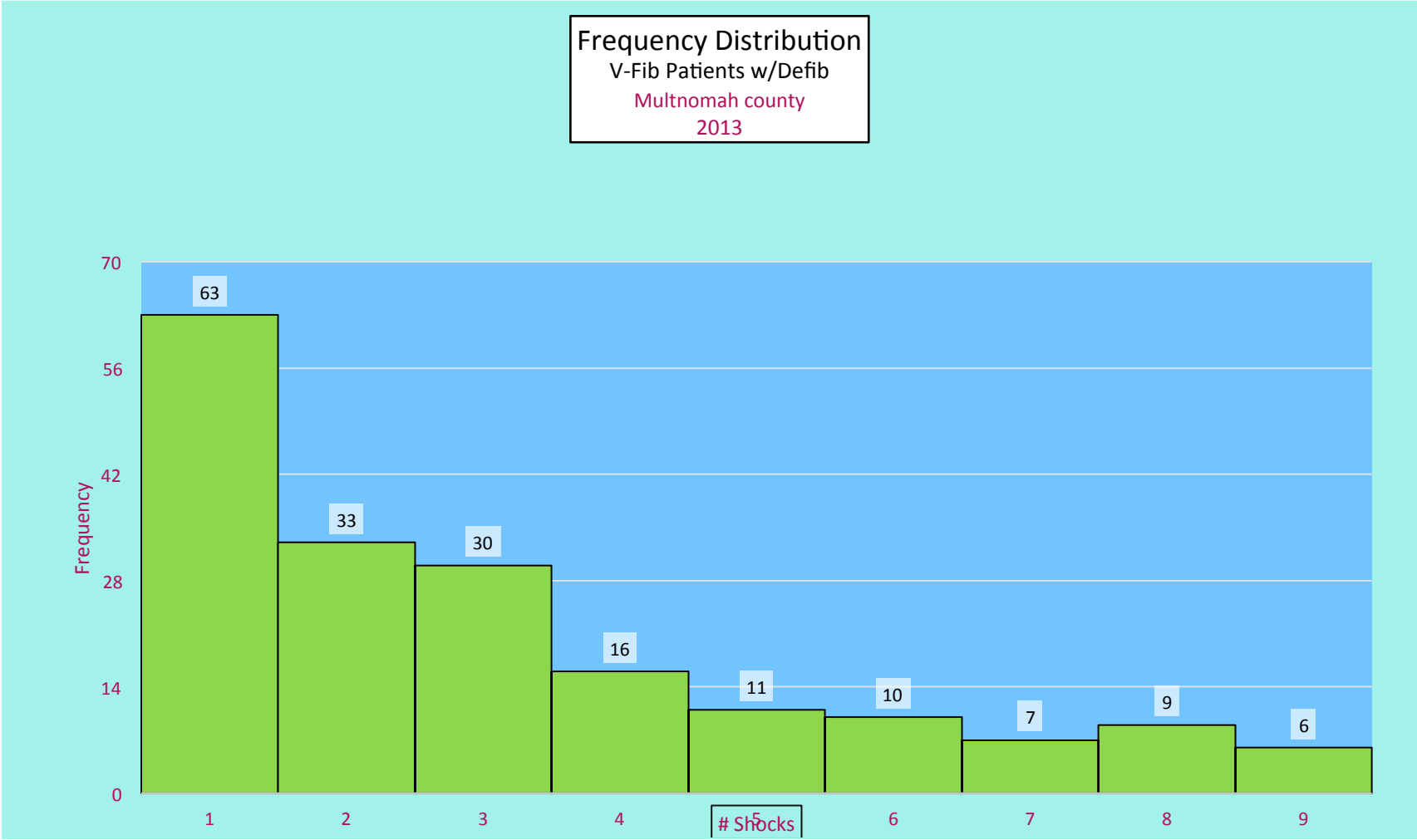
Refractory VF: Percent of VF Requiring Greater than 5 shocks 2006- 2103



MCEMS Defibrillation Shocks 2013 to 2015

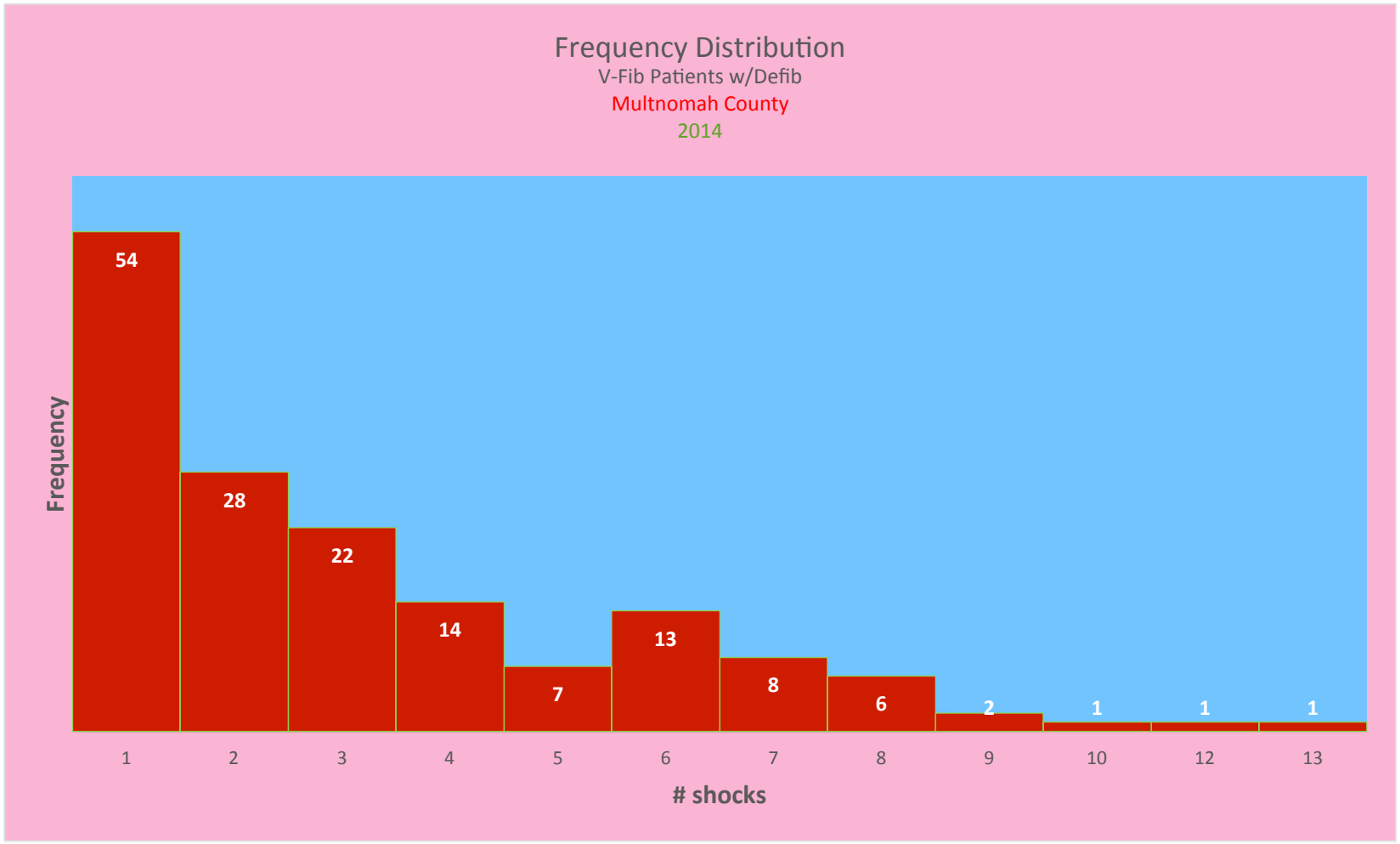


MCEMS Defibrillation Attempts 2013
"The Natural History of SSD"

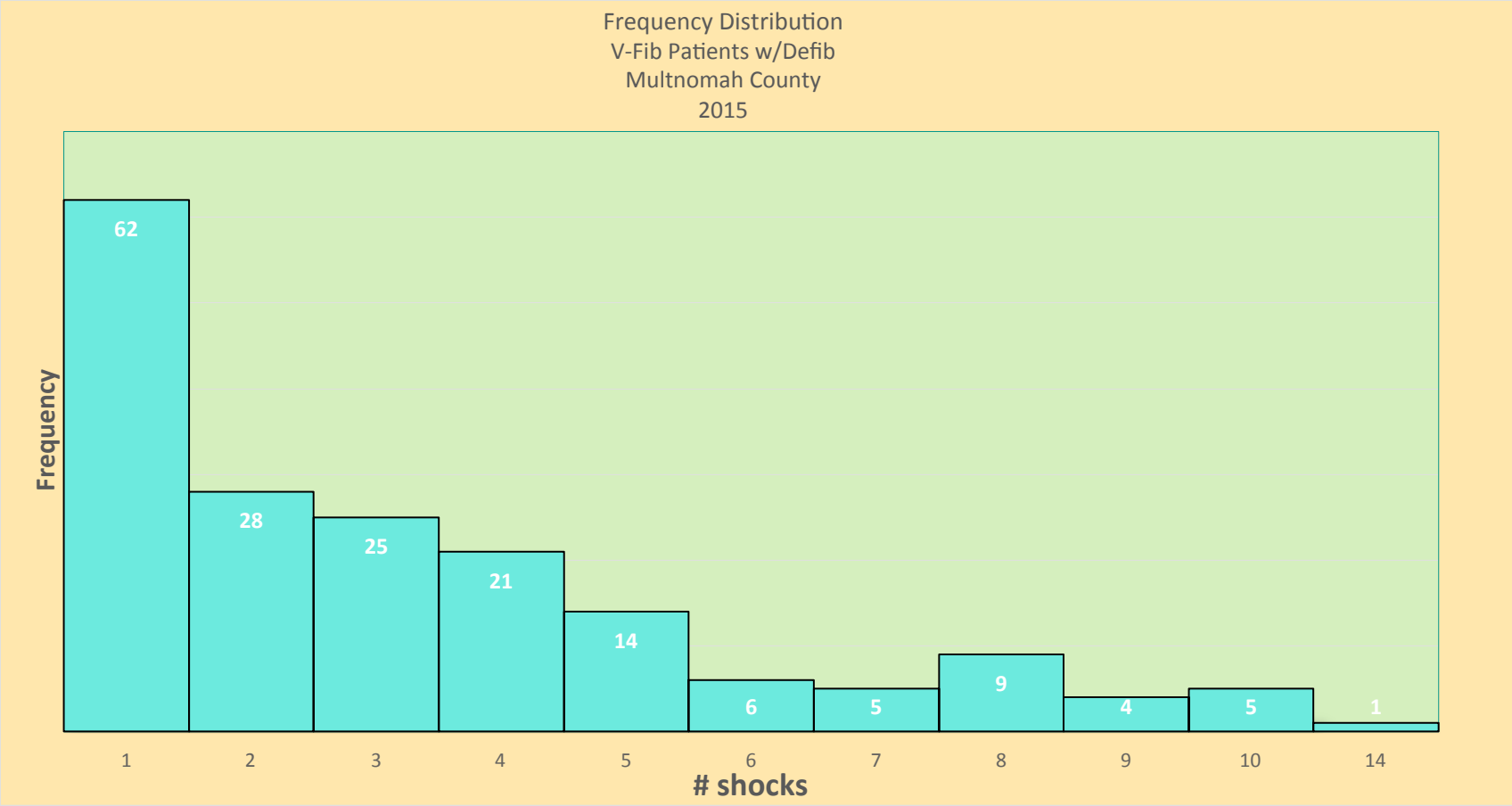


MCEMS Defibrillation Attempts 2014

1st Year of DSD



MCEMS Defibrillation Attempts 2015



Summary

- Double Sequential Defibrillation may be a viable therapy option for patients in refractory VF cardiac arrest.
- Our case series is the first to report survivors from a case series.
- Our data currently indicate that most patients who will convert will convert by the 2nd shock.
- DSD should be integrated with aggressive definitive intervention (Cardiac Cath/E-CPR) when appropriate.

The END