

# Pediatric Firearm Trauma

Ramin Jamshidi, MD FACS

NAEMS Pediatric Symposium

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# Disclosures



NO CONFLICTS OF INTEREST /  
RELATED INCOME

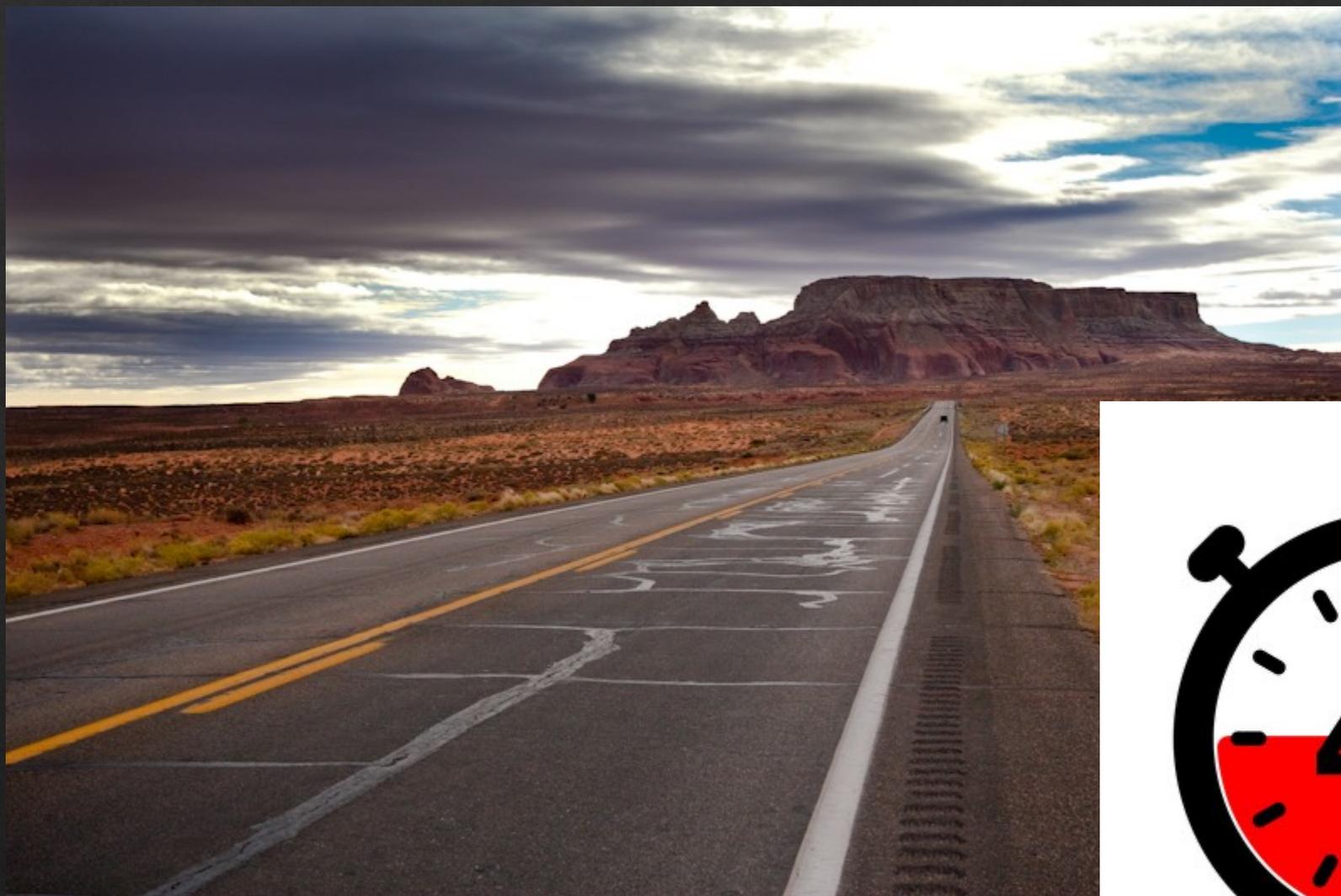


NOT A POLITICAL TALK

# Topics of Discussion

- ◆ Injury Evaluation
  - ◆ Types
  - ◆ Ballistics
  - ◆ Characterization
- ◆ Initial Management
  - ◆ Tourniquets
  - ◆ Balanced Resuscitation
  - ◆ Forensic Considerations
- ◆ Advanced Interventions
  - ◆ Thoracotomy
  - ◆ REBOA
- ◆ Epidemiology
  - ◆ Evolving Trends
  - ◆ Prevention
- ◆ Discussion & Questions





# Injury Identification

# Types of Firearm Injury

- ◇ Wounds
- ◇ Visceral injury
- ◇ Vascular injury
- ◇ Blast effects
- ◇ Emotional injury / PTSD

# Factors Affecting Injury

- ◆ Location of penetration

- ◆ Head

- ◆ Chest

- ◆ Abdomen

- ◆ Extremities

- ◆ Type of firearm and projectile

- ◆ Pellet / BB

- ◆ Pistol

- ◆ Shotgun

- ◆ Rifle

# Signs of Vascular Injury

# Signs of Vascular Injury

## HARD Signs

- ◇ Expanding hematoma
- ◇ Pulse deficit
- ◇ Pulsatile bleeding
- ◇ Thrill
- ◇ Bruit

## SOFT Signs

- ◇ History of pulsatile bleeding
- ◇ Proximity of wound to artery
- ◇ Non-expanding hematoma
- ◇ Neurologic deficit

# Pulse Quantification

◇ Ankle – Brachial Index

◇ 1930

◇ Ankle Systolic / Brachial Systolic

◇ Arterial Pulse Index

◇ 1991

◇ Extremity Systolic / Contralateral Systolic



# Ballistics

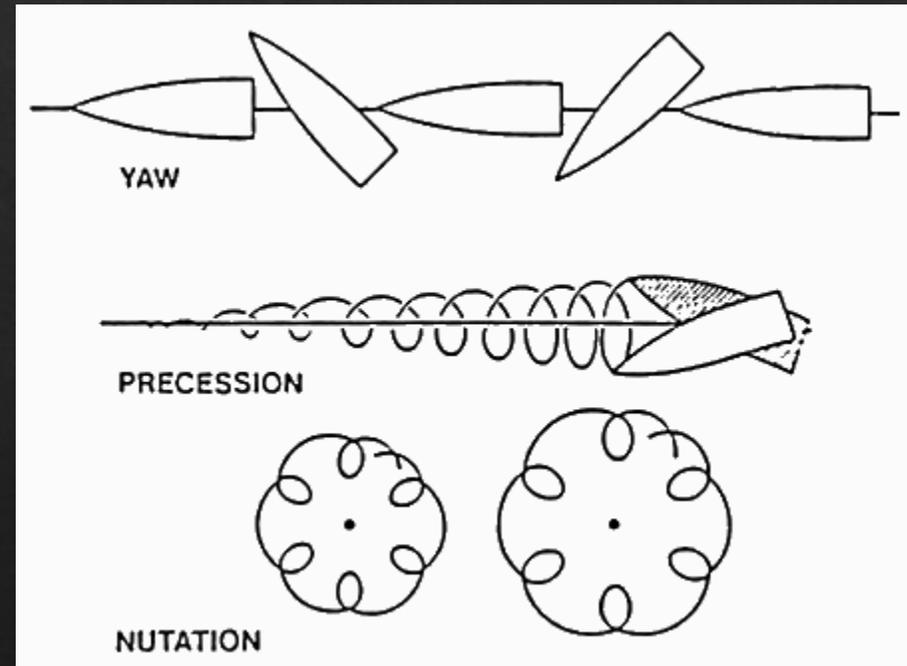
Multiple factors contribute to wound character:

- ◇ Distance
- ◇ Energy
- ◇ Caliber
- ◇ Projectile Type
- ◇ Tissue type



# Ballistics

- ◇ Complex dynamics
- ◇ Non-linear trajectory
- ◇ Blast effects  
& Cone of injury



# Ballistics

## Entrance Wounds

The **entrance wound** is normally smaller and quite symmetrical in comparison to the exit **wound**, which can sometimes be ragged with skin, tissue, and muscle and bone damage. **Entrance wounds** are often ringed with the residue of gunpowder and cordite - the two substances contained within a bullet. Dec 17, 2016

[Entrance and Exit Wounds - Explore Forensics](#)

[www.exploreforensics.co.uk](http://www.exploreforensics.co.uk) > [entrance-and-exit-wounds](#)

Physician accuracy 63% (2 holes)

... 26% if more holes

# Ballistics

- ◇ Document wounds and projectiles
  - ◇ Avoid stating “entry or exit”
- ◇ (Consider blast / regional injuries)
  - ◇ Avoid simply “connecting the dots”

# Injury Management

Pediatric

firearm injury initial management

is essentially the same as for

Adults

# Initial Management

- ◇ Minimize bleeding
- ◇ Rapidly stabilize
- ◇ Immediately transport







# Tourniquets

- ◇ Taboo for decades
- ◇ Resurgence in 2010s
- ◇ When to apply
- ◇ When to remove



Arterial vs Venous





# Benefits / Drawbacks

- ◇ Limits hemorrhage
- ◇ Frees rescuer hands
- ◇ Quickly applied
- ◇ Suitable for hostile environments
- ◇ Tissue damage at application site
- ◇ Distal tissue ischemia
- ◇ Time-sensitive (starts the clock)

# Tourniquets

◇ The pendulum swings

...and controversy persists

◇ **Proper use in the right patient can save a life!**

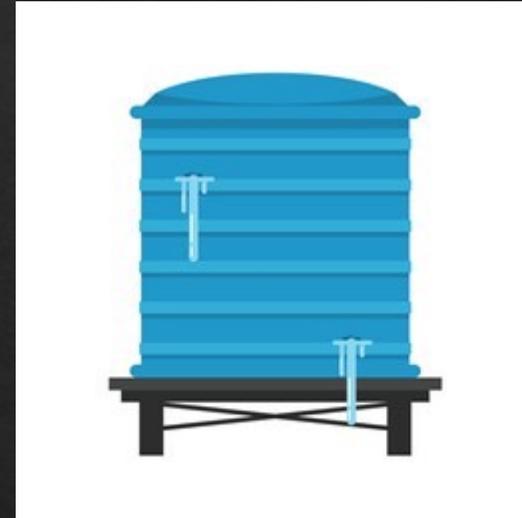
# “The Bottom Line”

- ◆ Apply for severe extremity hemorrhage
- ◆ Occlude pulsation
- ◆ Limit to 2 hours



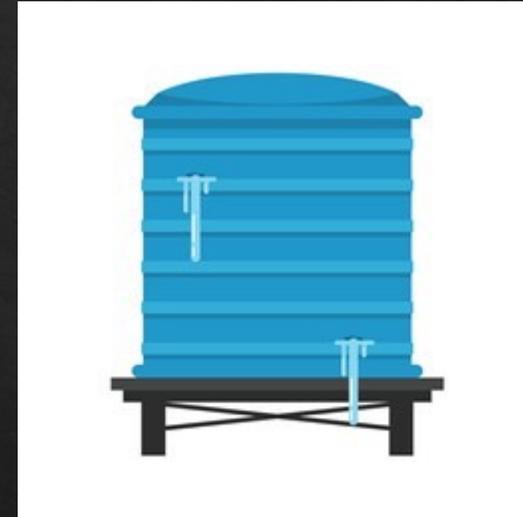
# Balanced Resuscitation

- ◇ Permissive Hypotension
- ◇ Hypotensive Resuscitation



# Balanced Resuscitation

- ◇ Permissive Hypotension
- ◇ Hypotensive Resuscitation
- ◇ Maintain perfusion  
while
- ◇ Limiting hemorrhage

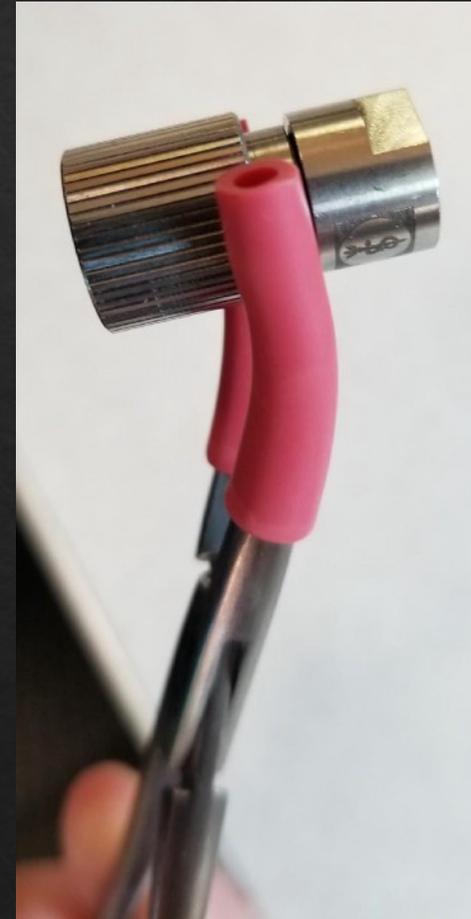


# Forensics

- ◆ Evidence must be preserved
  - ◆ Objective documentation
  - ◆ Avoidance of disruption
  - ◆ Prevention of tampering

# Forensics: Avoid Disruption

- ◇ Cut clothes in unaffected areas
- ◇ Store in paper bags
- ◇ Incisions exclude wounds
- ◇ Atraumatic projectile handling



# Forensics: Chain of Custody

- ◆ Relates to all collected items
- ◆ Minimize number of people involved
- ◆ Record of “links in the chain” of possession
- ◆ Hospital security ideal until PD arrives

Who Shoots A Kid?!

# Who Shoots A Kid?!



# Hospital Injury Management

# Hospital Care

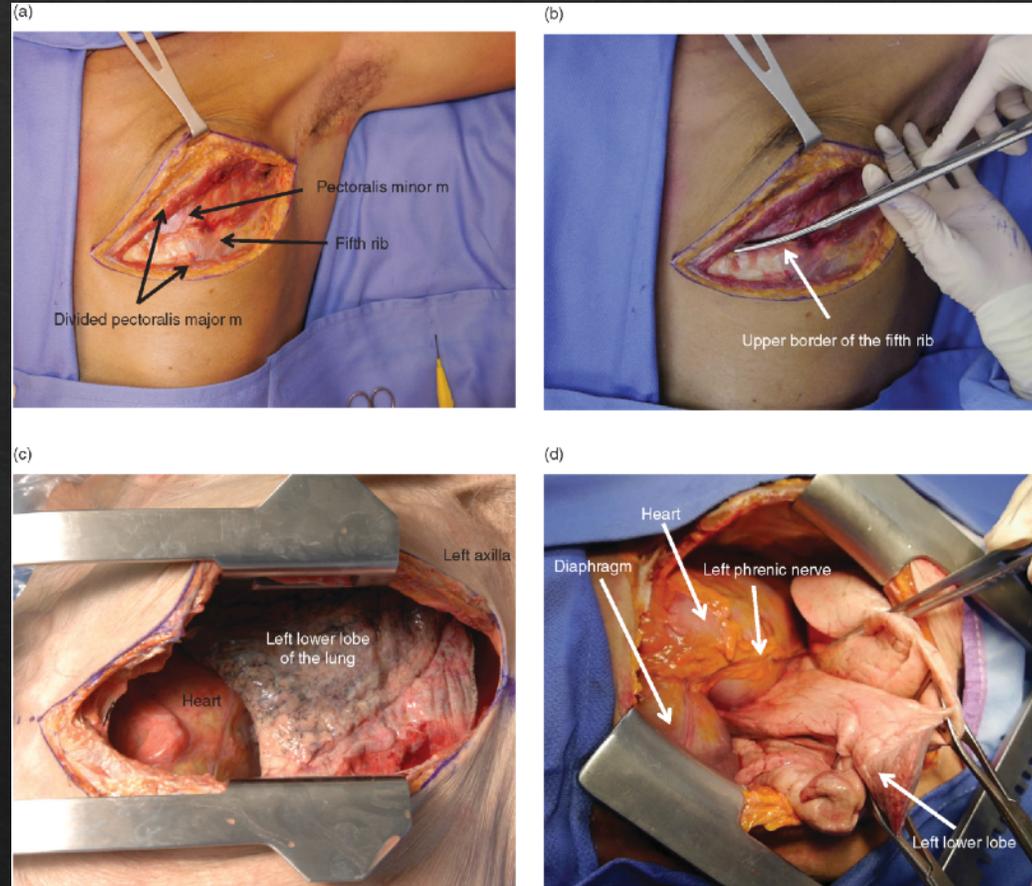
- ◆ Identify injuries and stabilize
- ◆ Resuscitation including blood administration
- ◆ Decision for operation or not
- ◆ Advanced interventions



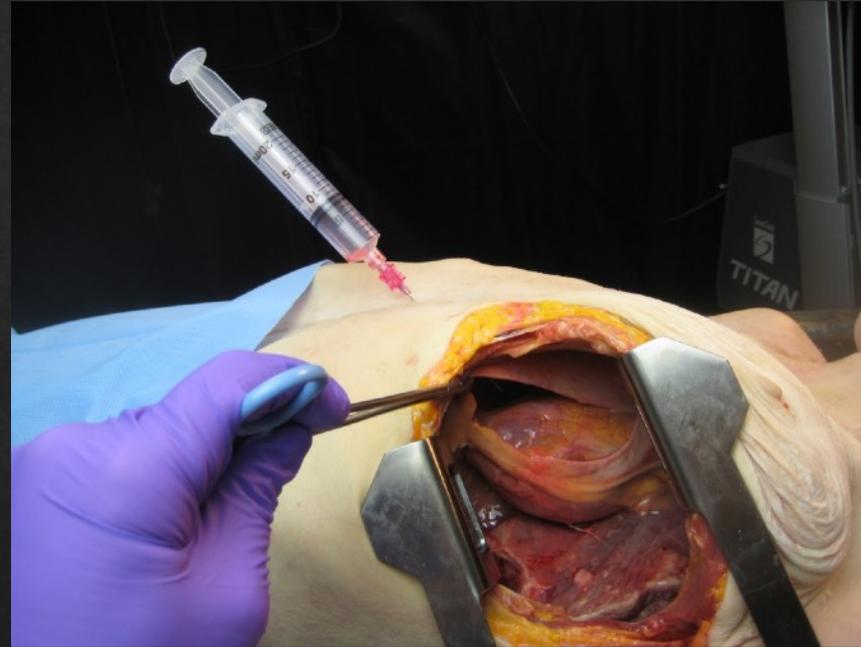
# Extreme Options for Severe Bleeding

- ◇ In non-compressible hemorrhage, death can occur before control
- ◇ Improved outcomes if we can:
  - ◇ Limit bleeding
  - ◇ Divert perfusion to head and heart
- ◇ Resuscitative Thoracotomy
  - ◇ “ED Thoracotomy”
  - ◇ “Cracking the chest”
- ◇ REBOA
  - ◇ Balloon occlusion of aorta
  - ◇ Wire / catheter procedure

# Resuscitative Thoracotomy



# Resuscitative Thoracotomy



# Resuscitative Thoracotomy



# Resuscitative Thoracotomy

Bold and heroic measure, but has drawbacks:

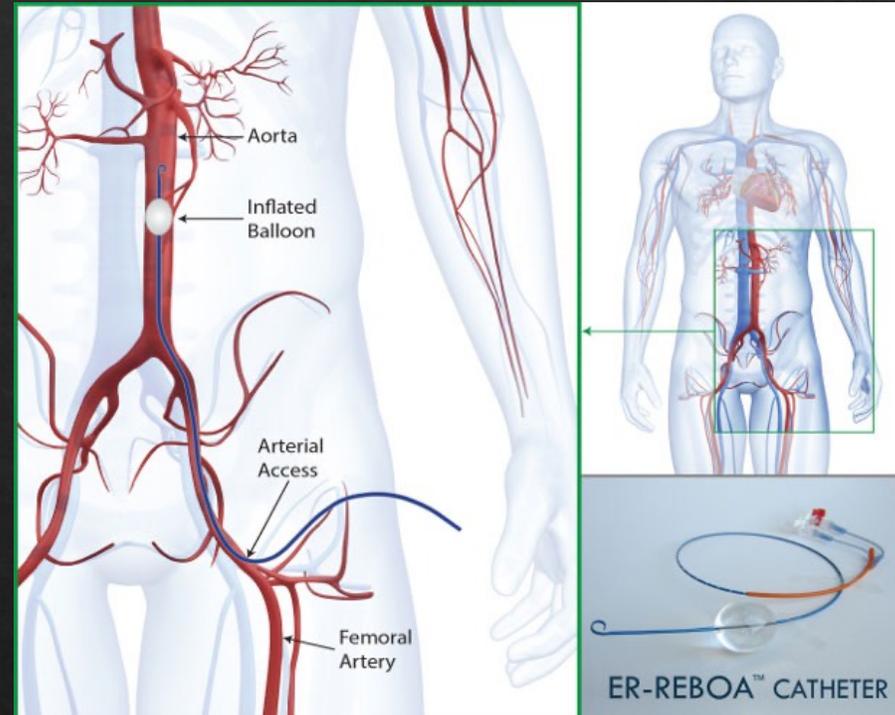
- ◇ Takes time
- ◇ Messy
- ◇ Secondary Injuries
  - ◇ Patient
  - ◇ Trauma team
- ◇ Outcomes still poor

REBOA

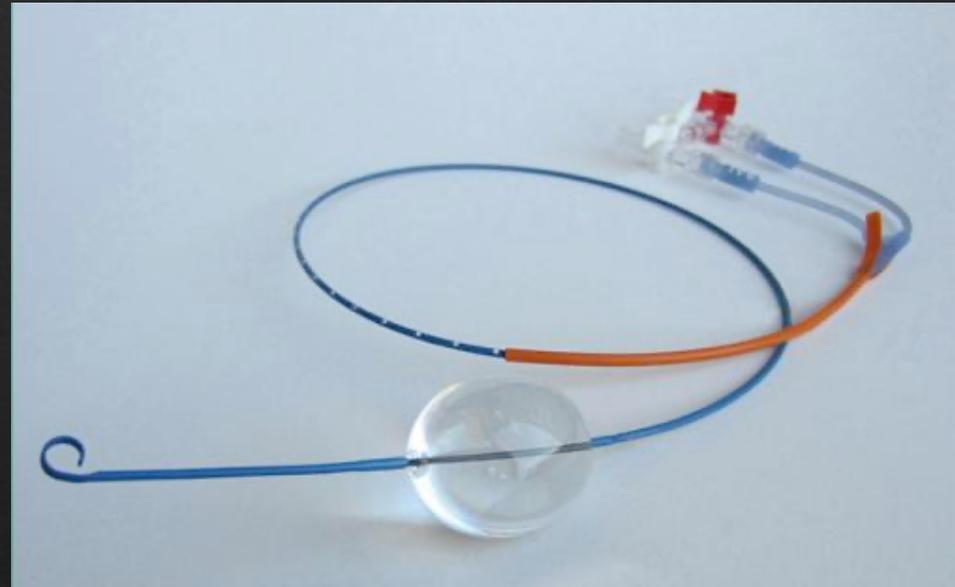
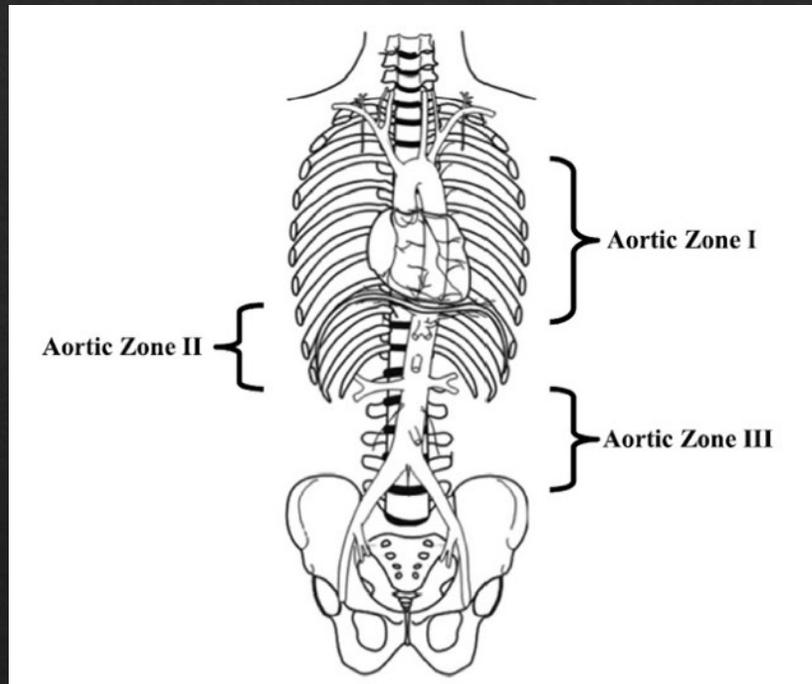
RESUSCITATIVE  
ENDOVASCULAR  
BALLOON  
OCCLUSION  
(OF) AORTA

# REBOA

- ◊ Resuscitative
- ◊ Endovascular
- ◊ Balloon
- ◊ Occlusion of
- ◊ Aorta



# REBOA



# Termination of Efforts

- ◇ Pediatric potential for recovery is amazing  
... but brain and heart die the fastest
- ◇ Time without signs of life
- ◇ Unrecoverable injuries
- ◇ Futility and Mercy

# Is It Futile?

- ◆ Scene control / safety
- ◆ Unknown possibilities
- ◆ Consciences
  - ◆ Care providers
  - ◆ Family
- ◆ Default to try / transport

# Hospital & EMS Partnership

- ◇ Transition can be chaotic – stay focused
- ◇ Stay and ask questions / discuss or leave a card
- ◇ Participate in debriefing (standing invitation)

# Hospital & EMS Partnership

- ◇ Transition can be chaotic – stay focused
- ◇ Stay and ask questions / discuss or leave a card
- ◇ Participate in debriefing (standing invitation)
- ◇ Caring for these patients is traumatic for us all (as they “should” be)

Who Shoots A Kid?!

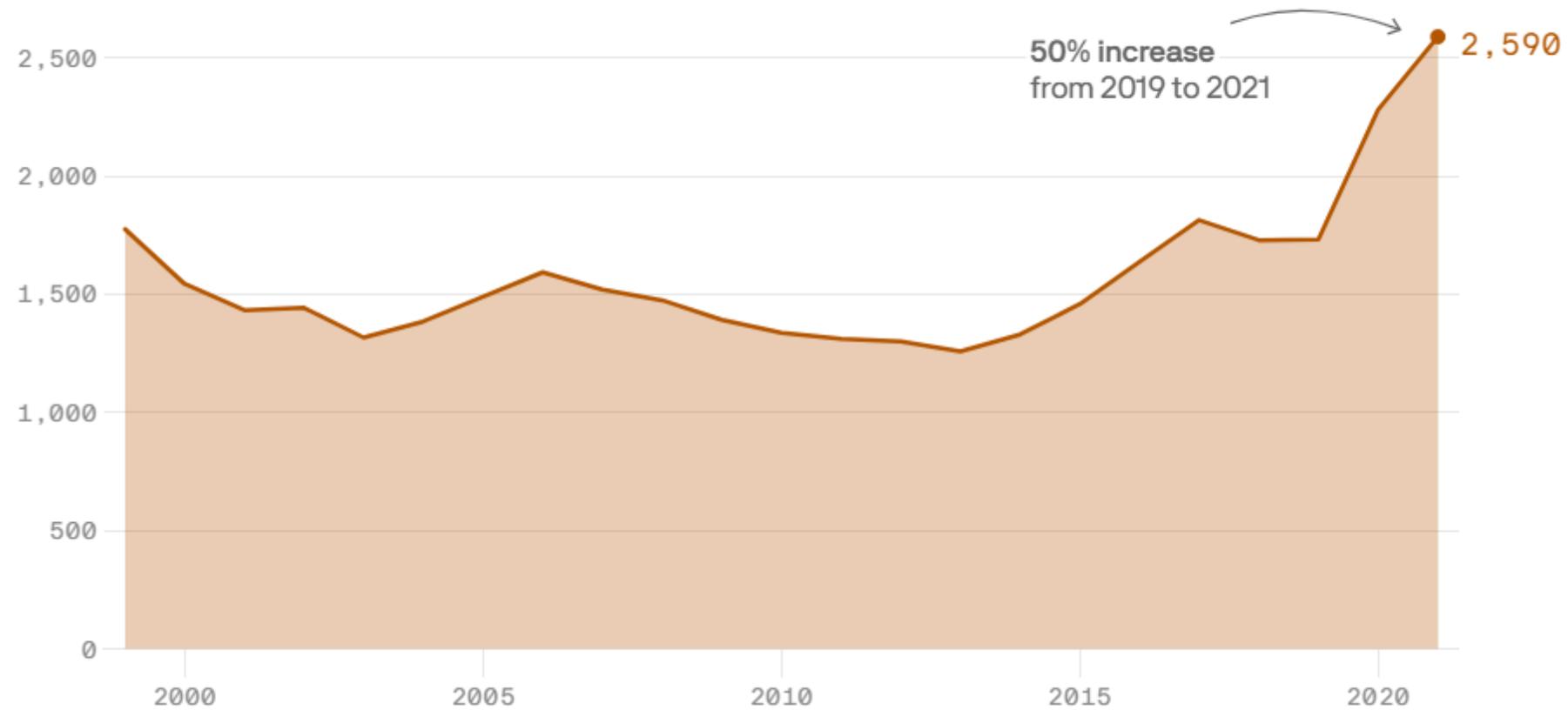
Injury Epidemiology  
(a changing world)

# Causes of Death in US

Rank	Age Groups										All Ages
	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	
1	Congenital Anomalies 4,043	<b>Unintentional Injury</b> 1,153	<b>Unintentional Injury</b> 685	<b>Unintentional Injury</b> 881	<b>Unintentional Injury</b> 15,117	<b>Unintentional Injury</b> 31,315	<b>Unintentional Injury</b> 31,057	Malignant Neoplasms 34,589	Malignant Neoplasms 110,243	Heart Disease 556,665	Heart Disease 696,962
2	Short Gestation 3,141	Congenital Anomalies 382	Malignant Neoplasms 382	<b>Suicide</b> 581	<b>Homicide</b> 6,466	<b>Suicide</b> 8,454	Heart Disease 12,177	Heart Disease 34,169	Heart Disease 88,551	Malignant Neoplasms 440,753	Malignant Neoplasms 602,350
3	SIDS 1,389	<b>Homicide</b> 311	Congenital Anomalies 171	Malignant Neoplasms 410	<b>Suicide</b> 6,062	<b>Homicide</b> 7,125	Malignant Neoplasms 10,730	<b>Unintentional Injury</b> 27,819	COVID-19 42,090	COVID-19 282,836	COVID-19 350,831
4	<b>Unintentional Injury</b> 1,194	Malignant Neoplasms 307	<b>Homicide</b> 169	<b>Homicide</b> 285	Malignant Neoplasms 1,306	Heart Disease 3,984	<b>Suicide</b> 7,314	COVID-19 16,964	<b>Unintentional Injury</b> 28,915	Cerebro-vascular 137,392	<b>Unintentional Injury</b> 200,955
5	Maternal Pregnancy Comp. 1,116	Heart Disease 112	Heart Disease 56	Congenital Anomalies 150	Heart Disease 870	Malignant Neoplasms 3,573	COVID-19 6,079	Liver Disease 9,503	Chronic Low. Respiratory Disease 18,816	Alzheimer's Disease 132,741	Cerebro-vascular 160,264
6	Placenta Cord Membranes 700	Influenza & Pneumonia 84	Influenza & Pneumonia 55	Heart Disease 111	COVID-19 501	COVID-19 2,254	Liver Disease 4,938	Diabetes Mellitus 7,546	Diabetes Mellitus 18,002	Chronic Low. Respiratory Disease 128,712	Chronic Low. Respiratory Disease 152,657
7	Bacterial Sepsis 542	Cerebro-vascular 55	Chronic Low. Respiratory Disease 54	Chronic Low. Respiratory Disease 93	Congenital Anomalies 384	Liver Disease 1,631	<b>Homicide</b> 4,482	<b>Suicide</b> 7,249	Liver Disease 16,151	Diabetes Mellitus 72,194	Alzheimer's Disease 134,242
8	Respiratory Distress 388	Perinatal Period 54	Cerebro-vascular 32	Diabetes Mellitus 50	Diabetes Mellitus 312	Diabetes Mellitus 1,168	Diabetes Mellitus 2,904	Cerebro-vascular 5,686	Cerebro-vascular 14,153	<b>Unintentional Injury</b> 62,796	Diabetes Mellitus 102,188
9	Circulatory System Disease 386	Septicemia 43	Benign Neoplasms 28	Influenza & Pneumonia 50	Chronic Low. Respiratory Disease 220	Cerebro-vascular 600	Cerebro-vascular 2,008	Chronic Low. Respiratory Disease 3,538	<b>Suicide</b> 7,160	Nephritis 42,675	Influenza & Pneumonia 53,544
10	Neonatal Hemorrhage 317	Benign Neoplasms 35	<b>Suicide</b> 20	Cerebro-vascular 44	Complicated Pregnancy 191	Complicated Pregnancy 594	Influenza & Pneumonia 1,148	<b>Homicide</b> 2,542	Influenza & Pneumonia 6,295	Influenza & Pneumonia 42,511	Nephritis 52,547

# Gun deaths among U.S. kids and teens under 18

Annually; 1999-2021



Reproduced from [Pew Research Center](#); Chart: Axios Visuals



*The* NEW ENGLAND JOURNAL *of* MEDICINE

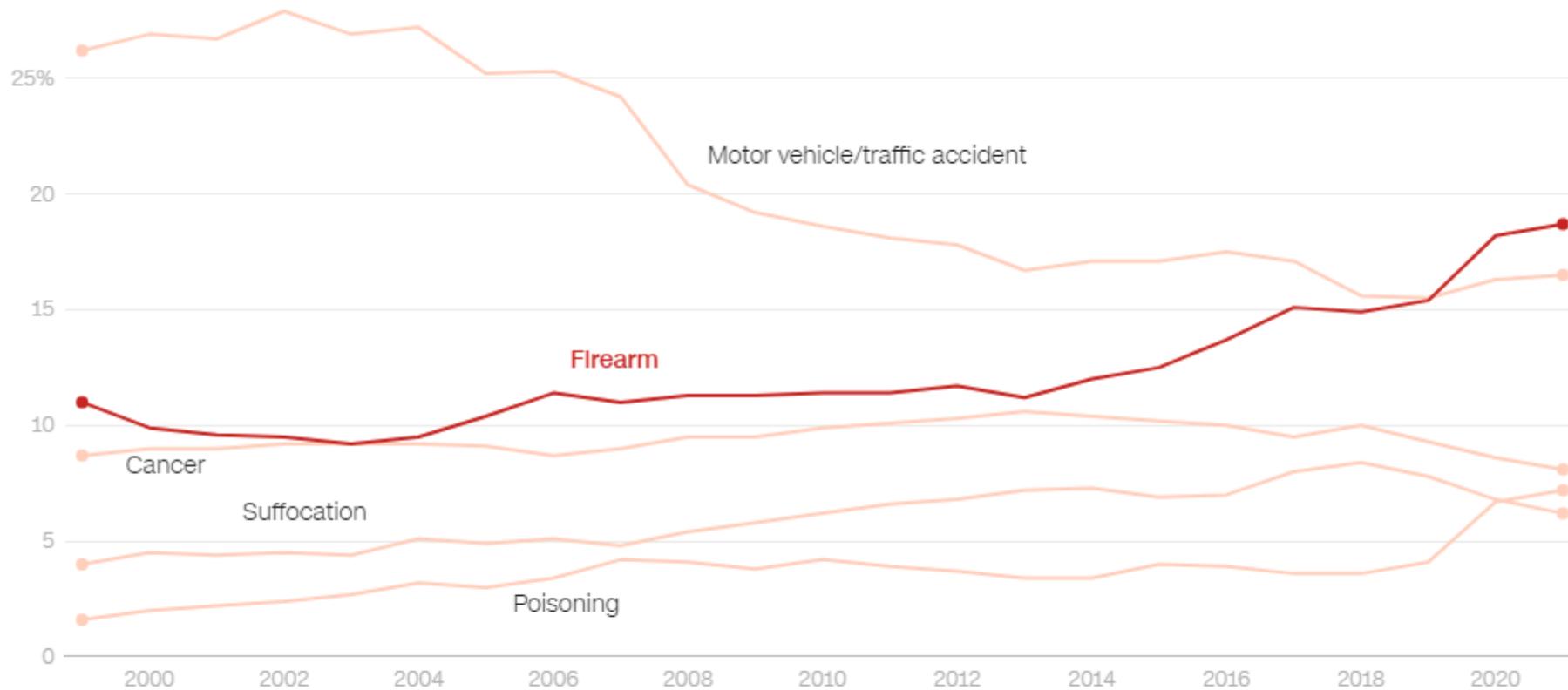
Perspective

APRIL 21, 2022

**Crossing Lines — A Change in the Leading Cause of Death  
among U.S. Children**

Lois K. Lee, M.D., M.P.H., Katherine Douglas, M.D., and David Hemenway, Ph.D.

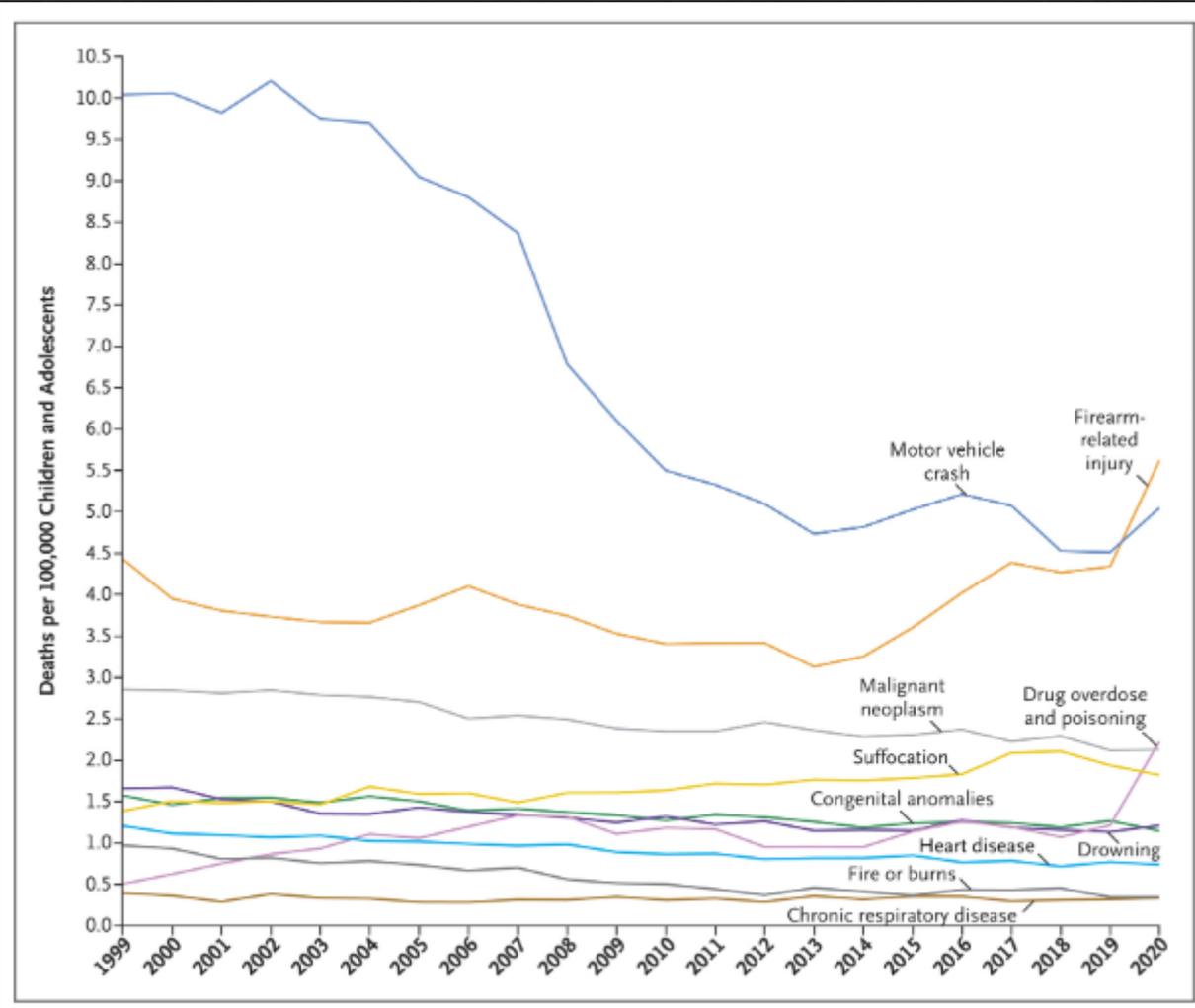
Top five causes of death for children ages 1 to 18, as a percentage of all causes



Note: Data shows the top five "injury mechanism and all other leading causes of death" as collected by the CDC Wonder database, as of 2021.

Source: Centers for Disease Control and Prevention Wonder database

Graphic: Annette Choi, CNN



## The U.S. Is the Only Country Among Its Peers in Which Guns Are the Leading Cause of Death Among Children and Teens

Ranking (number of deaths) by leading cause of mortality for children and teens ages 1-19 years, U.S. and peer countries, 2020

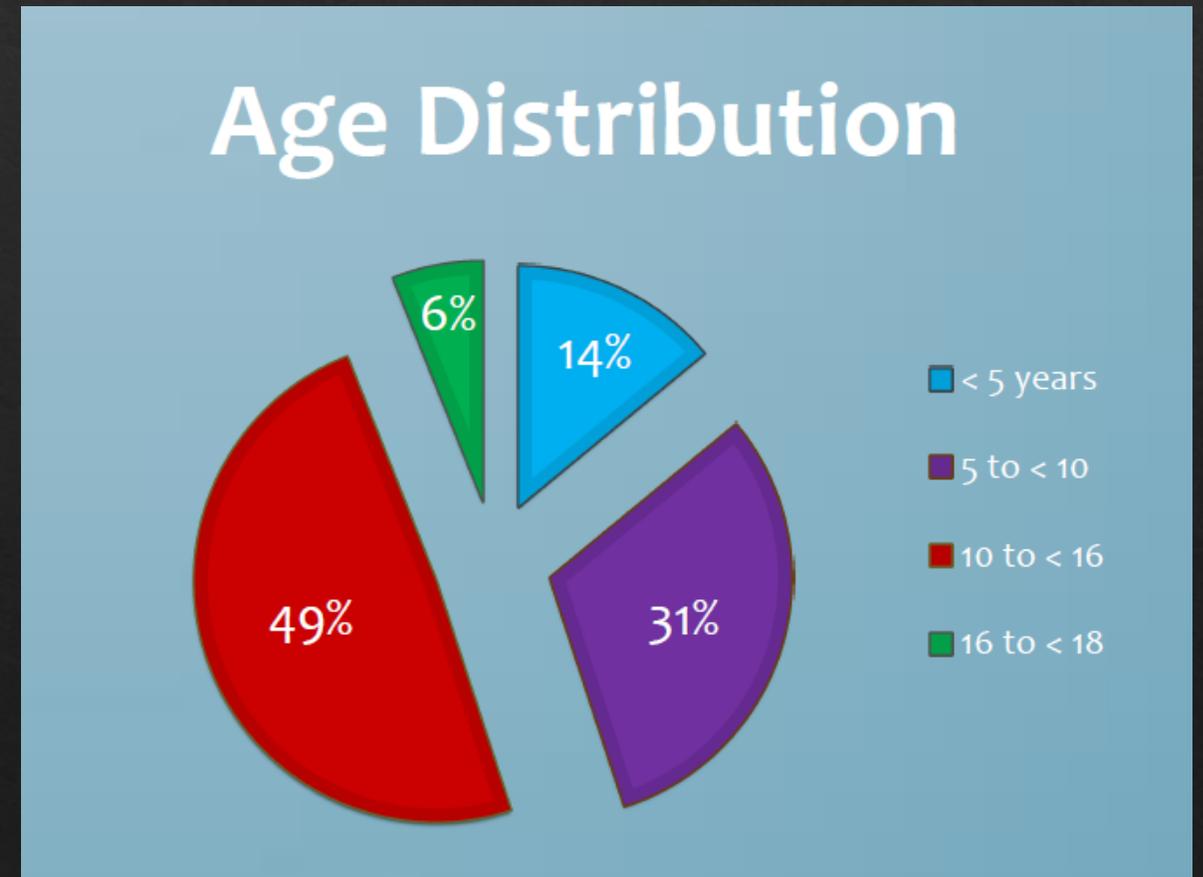
	Firearm	Motor vehicles	Other injuries	Congenital disease	Cancer	Substance use	Heart disease
 U.S.	<b>1</b> (4,357)	<b>2</b> (4,112)	<b>3</b> (3,879)	<b>4</b> (3,166)	<b>5</b> (1,767)	<b>6</b> (1,552)	<b>7</b> (687)
 Australia	<b>11</b> (10)	<b>1</b> (188)	<b>4</b> (95)	<b>3</b> (104)	<b>2</b> (160)	<b>8</b> (19)	<b>6</b> (22)
 Austria	<b>9</b> (4)	<b>1</b> (49)	<b>4</b> (30)	<b>2</b> (42)	<b>2</b> (42)	<b>6</b> (9)	<b>7</b> (6)
 Belgium	<b>9</b> (5)	<b>1</b> (73)	<b>3</b> (42)	<b>3</b> (42)	<b>2</b> (64)	<b>11</b> (4)	<b>7</b> (10)
 Canada	<b>5</b> (48)	<b>1</b> (294)	<b>4</b> (153)	<b>3</b> (165)	<b>2</b> (234)	<b>6</b> (45)	<b>8</b> (33)
 France	<b>8</b> (48)	<b>1</b> (471)	<b>3</b> (300)	<b>4</b> (288)	<b>2</b> (432)	<b>12</b> (17)	<b>6</b> (70)
 Germany	<b>13</b> (14)	<b>2</b> (406)	<b>4</b> (194)	<b>3</b> (303)	<b>1</b> (411)	<b>9</b> (29)	<b>6</b> (77)
 Japan	<b>15</b> (5)	<b>2</b> (365)	<b>4</b> (313)	<b>3</b> (333)	<b>1</b> (492)	<b>14</b> (9)	<b>6</b> (114)

# How Pediatric Firearm Injuries Occur

- ◇ Bystander
- ◇ Exploration / Misadventure
- ◇ Intentional Self-Injury
- ◇ Malice

# “Young Guns”

- ◇ 170 pediatric GSW  
120 known shooter age
- ◇ 91% shooters < 18 years
- ◇ Shooter ages 2 – 17 years



# Indianapolis father grieves the loss of 6-year-old son who accidentally shot himself

"Without him, I don't got myself, I don't feel right," said Billy Boyd, the father of 6-year-old Billy Mack, who accidentally shot himself Sunday afternoon.



Author: John Doran

Published: 7:04 PM EDT April 17, 2023

Updated: 9:14 AM EDT April 18, 2023



ARLINGTON

# Arlington Toddler Dies After Accidentally Shooting Self With Gun Found in Home

Arlington Police say a 2-year-old boy found the gun in an older sibling's bedroom

By [Sophia Beausoleil](#) • Published April 4, 2023 • Updated on April 4, 2023 at 7:06 pm



## 1-year-old boy accidentally shot by 4-year-old brother in Texas, authorities say

The child is expected to survive.

By [Morgan Winsor](#)  
May 17, 2023, 2:33 AM



U.S. >

## 4-year-old-girl accidentally shot and killed by another child in Illinois

BY S. DEV  
JUNE 1, 2023 / 3:46 PM / CBS NEWS



NEWS

# Boy, 7, 'Traumatized' After Accidentally Shooting 9-Year-Old Sister Dead

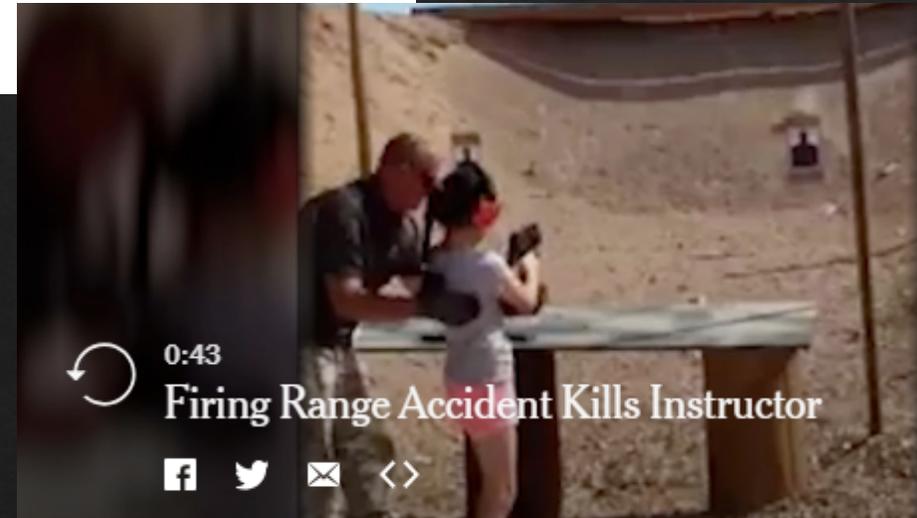
BY **CHLOE MAYER** ON 5/16/23 AT 11:11 AM EDT

## Child accidentally kills another child with father's gun

The child was killed with his father's gun, according to police.

By [Nadine El-Bawab](#)

June 1, 2023, 10:14 AM



# How Pediatric Firearm Injuries Occur

- ◇ Bystander
- ◇ Exploration / Misadventure
- ◇ Intentional self-injury
- ◇ Malice
- ◇ Sometimes humorous
- ◇ Usually distressing
- ◇ Often immeasurably tragic
- ◇ Always avoidable

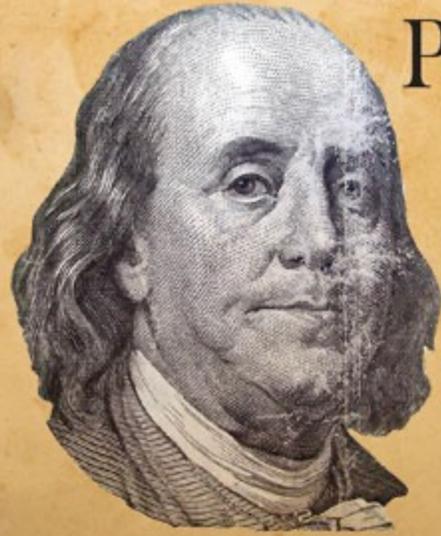
**More than  
352,000  
students have experienced gun  
violence at school since  
Columbine**

There have been 380 school shootings since 1999, according to Post data









*An ounce of*  
**PREVENTION**  
*is worth a*  
**POUND OF**  
**CURE**  
*- Benjamin Franklin*

# Prevention via Collaborative Discussion

- ◆ Primary prevention = universal trauma priority
- ◆ Firearm access / security = major risk factor
- ◆ Intimate partner violence, teen angst and impulsivity...
- ◆ Critical piece of Social History  
("are you safe at home?")



# CliffsNotes™

## ◆ Characterization

- ◆ Hard vs soft signs of bleeding
- ◆ Objective documentation

## ◆ Initial Management

- ◆ Hypotensive resusc.
- ◆ Judicious tourniquet use

## ◆ Ballistics & Forensics

- ◆ Entry / exit not obvious
- ◆ Preserve evidence (& its custody)

## ◆ Pedi firearm injuries on the rise

- ◆ Discuss access / safety
- ◆ NOT political – work TOGETHER

**THANK YOU** for all you do – stay and talk with us!!

# Questions / Discussion



# Thank You!

Ramin Jamshidi

[rjamshidi@phoenixchildrens.com](mailto:rjamshidi@phoenixchildrens.com)