

# Post Crash Fire and Blunt Force Fatal Injuries in U.S. Registered, Type Certificated Rotorcraft



A Collaborative Project between:

Rotorcraft Directorate Standards Staff, Safety Management Group  
and

CAMI Autopsy Program Team, Medical Case Research Physician, and  
CAMI Biostatistician

Presented By: Lee Roskop, FAA

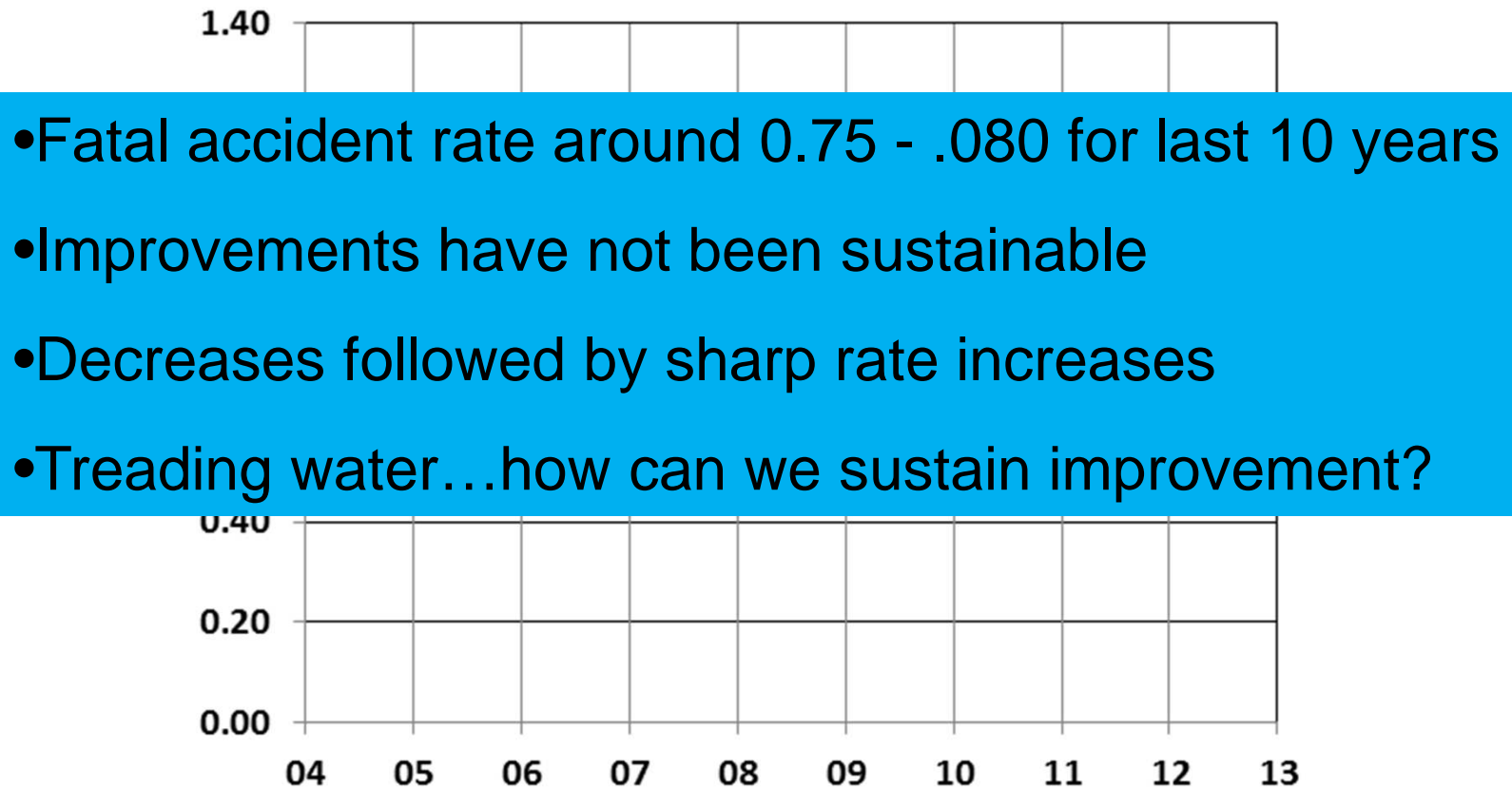
Date: December 2014



Federal Aviation  
Administration



# Estimated U.S. Rotorcraft Fatal Accident Rates Per 100,000 hours – 10 Year Look Back



- Fatal accident rate around 0.75 - .080 for last 10 years
- Improvements have not been sustainable
- Decreases followed by sharp rate increases
- Treading water...how can we sustain improvement?

Historic rotorcraft flight hours extracted from FAA's General Aviation and Part 135 Activity Survey. Years 11 & 13 based on FAA's FY2013-2033 Forecast.



# Where should we start in learning more about fatal accidents?

- **Post Crash Fire (PCF)**
  - IHST data
    - PCF was most frequently cited Sub-Occurrence Category for U.S. fatal accidents in IHST's early analysis work.
  - True effect not well understood
    - Often unclear from investigative reports whether PCF was contributory to fatalities or just present in the accident.
  - High interest area
    - Investigative authorities, regulatory authorities, and public.



# FAA Collaborative Study Initiated

- **Rotorcraft Directorate**
  - Standards Staff
  - Safety Management Group
- **Civil Aerospace Medical Institute (CAMI)**
  - CAMI Autopsy Program Team
  - Medical Case Research Physician
  - CAMI Biostatistician



# Approach to Study

- **5 years of data available**
  - 10/13/2008 to 9/27/2013
- **Criteria for inclusion in the data set**
  - U.S. Registered
  - Type Certificated Rotorcraft
  - Fatal Accidents
- **Autopsy results available from CAMI for review**
  - Pilot
  - Passengers, if pilot certificated



# Quantity of Data

- **NTSB records that met criteria for inclusion**
  - 125 fatal accidents from 10/13/08 to 9/27/13
- **CAMI's autopsy data accounted for 78% of NTSB records (97 of 125 fatal accidents)**
  - For the remaining 28 NTSB records, CAMI does not collect autopsies for cases where:
    - Aircraft was U.S. registered but operating outside the U.S. (19 cases in this study)
    - The pilot was not fatally injured (9 cases in this study)



# Analysis method

- **Initial analysis by the Rotorcraft Directorate**
  - Used autopsy data to assess the following:
    - Did a post crash fire (PCF) occur?
    - If PCF was present, did it contribute to a fatality?
- **Subsequent review**
  - CAMI's Medical Research Team – Medical Case Review Physician
  - Directorate incorporated all CAMI's recommended changes
- **Organization of results**
  - By Certification Basis
  - By Make/Model



# Conclusions

- **Crash resistant fuel systems work to:**
  - **Decrease the occurrence of PCF**
    - Part 27 Rotorcraft without crash resistant fuel system
      - 39% (30/77) had a PCF
    - Part 27 Rotorcraft with crash resistant fuel system
      - 10% (1/10) had a PCF
  - **Decrease deaths attributable to PCF**
    - Part 27 Rotorcraft without crash resistant fuel systems
      - If PCF occurred (30 cases), contributed to fatality at 20% rate (6/30)
    - Part 27 Rotorcraft with crash resistant fuel systems
      - If PCF occurred (1 case), it did not contribute to fatality (0/1)





# Conclusions (continued)

- **When PCF occurred, cause of death was typically blunt force trauma rather than thermal injuries.**
  - **Part 27 Rotorcraft without crash resistant fuel system**
    - 30 cases of fatal accidents w/PCF; 80% (24/30) were fatal from blunt force
  - **Part 27 Rotorcraft with crash resistant fuel system**
    - The only case of fatal accident w/PCF was fatal from blunt force



# Conclusions (continued)

For Part 27 rotorcraft without a crash resistant fuel tank:

- Most PCF data did not suggest significant differences for the individual models that provided the largest sample of data.
- 83% of data (64/77 cases) came from 6 models/4 OEMs
  - Same 6 models accounted for 50% of 2014's registered U.S. rotorcraft fleet
- Comparable rates of:
  - PCF occurrence
  - PCF as contributory to the fatalities



**The data suggested blunt force trauma is the bigger concern in fatal rotorcraft accidents, even in cases of post crash fire...**

**...but what were the specific blunt force injuries that were documented in the fatal accidents?**



# Past and Present Research

- **Baseline data: Taneja & Wiegmann study**
  - Published April 2003
  - Data from 74 fatal helicopter accidents, 1993-1999
  - Injuries classified by body region/organ system
- **Data used for comparison**
  - Civil Aerospace Medical Institute autopsy data
  - Data from 97 fatal helicopter accidents, 2008-2013
  - Classified data using injury categories from Taneja and Wiegmann study



# Limitations

- **The level of detail for blunt force injuries documented in autopsy reports varies by U.S. state and by individual examiner.**
- **Could not narrow cause of death to one specific blunt force injury in each accident.**
  - Even in cases where injuries are well detailed, overall cause of death is typically listed as multiple blunt force injuries.



# Approach to Study

- **Similar to Post Crash Fire Study**
  - Reviewed autopsies from each case
  - Made note of each injury documented
- **Categorized injuries according to Taneja & Wiegmann's classification method**
  - Two broad classifications:
    - Bony Injuries
    - Organ/Visceral Injuries
  - Many sub-categories under two broad classifications



# Approach to Study (continued)

- **Analysis via statistical comparison**
  - Goal of identifying if statistically significant differences existed between corresponding injury categories documented in the 2014 study and the 2003 Taneja & Wiegmann study.
  - Used the following statistical methods:
    - Chi Squared Analysis using  $p < .05$  as measure of significance
    - Fisher's exact test for limited cases where Chi Squared Analysis was not appropriate
    - 95% confidence interval calculations



# Validation of Results

- **Autopsy analysis**
  - Reviewed, corrected, and final concurrence by CAMI's Medical Research Physician
- **Statistical analysis**
  - CAMI Biostatistician
    - Recommended appropriate statistical tests
    - Accomplished chi squared analysis and Fisher's exact test
    - Validated all results
  - CAMI Medical Research Physician
    - Reviewed all results



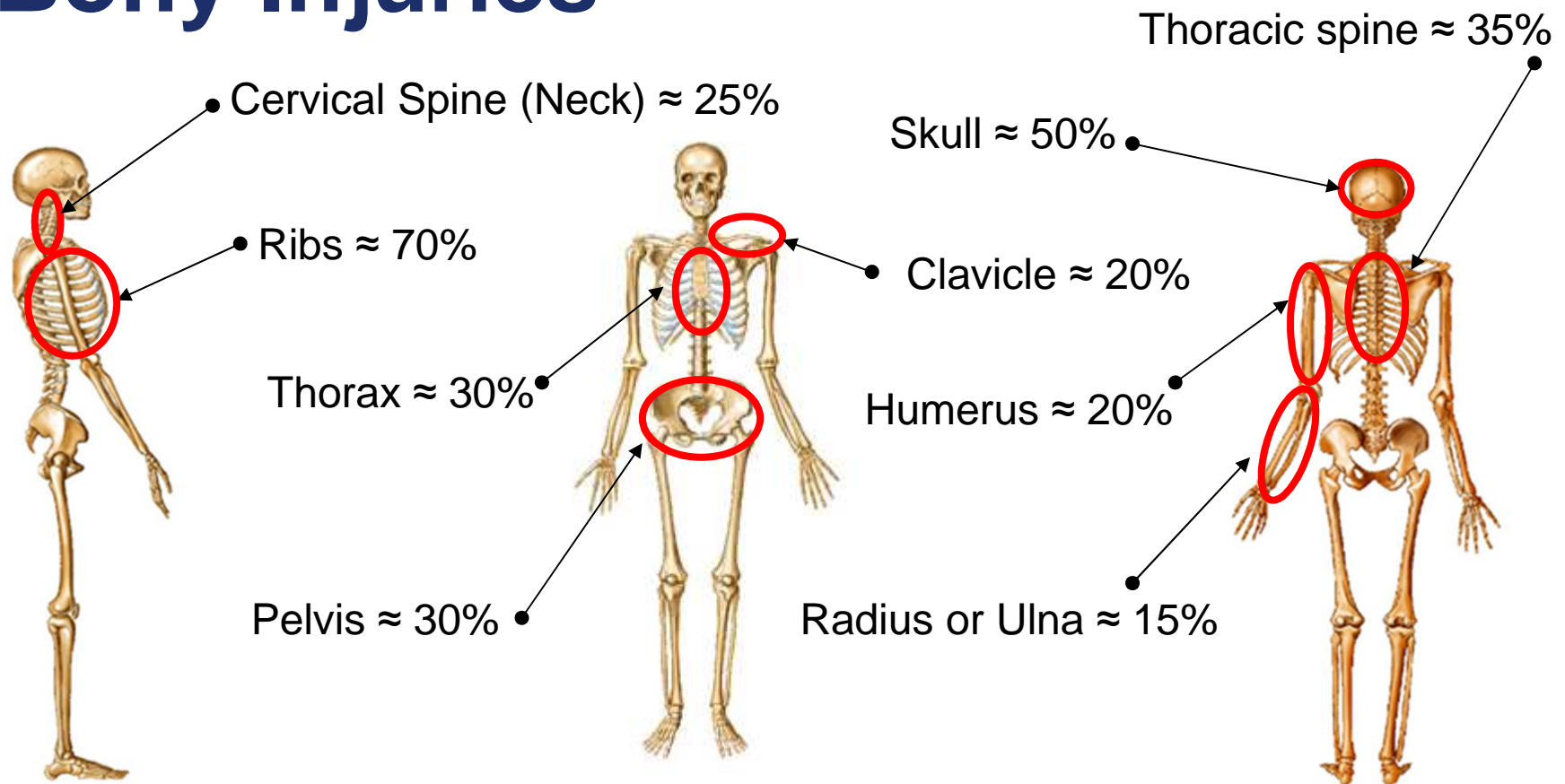


# Results

- **No statistically significant difference between the 2014 study and the 2003 Taneja & Wiegmann study for:**
  - 9 of 14 categories of bony injuries
  - 7 of 7 categories of organ/visceral injuries



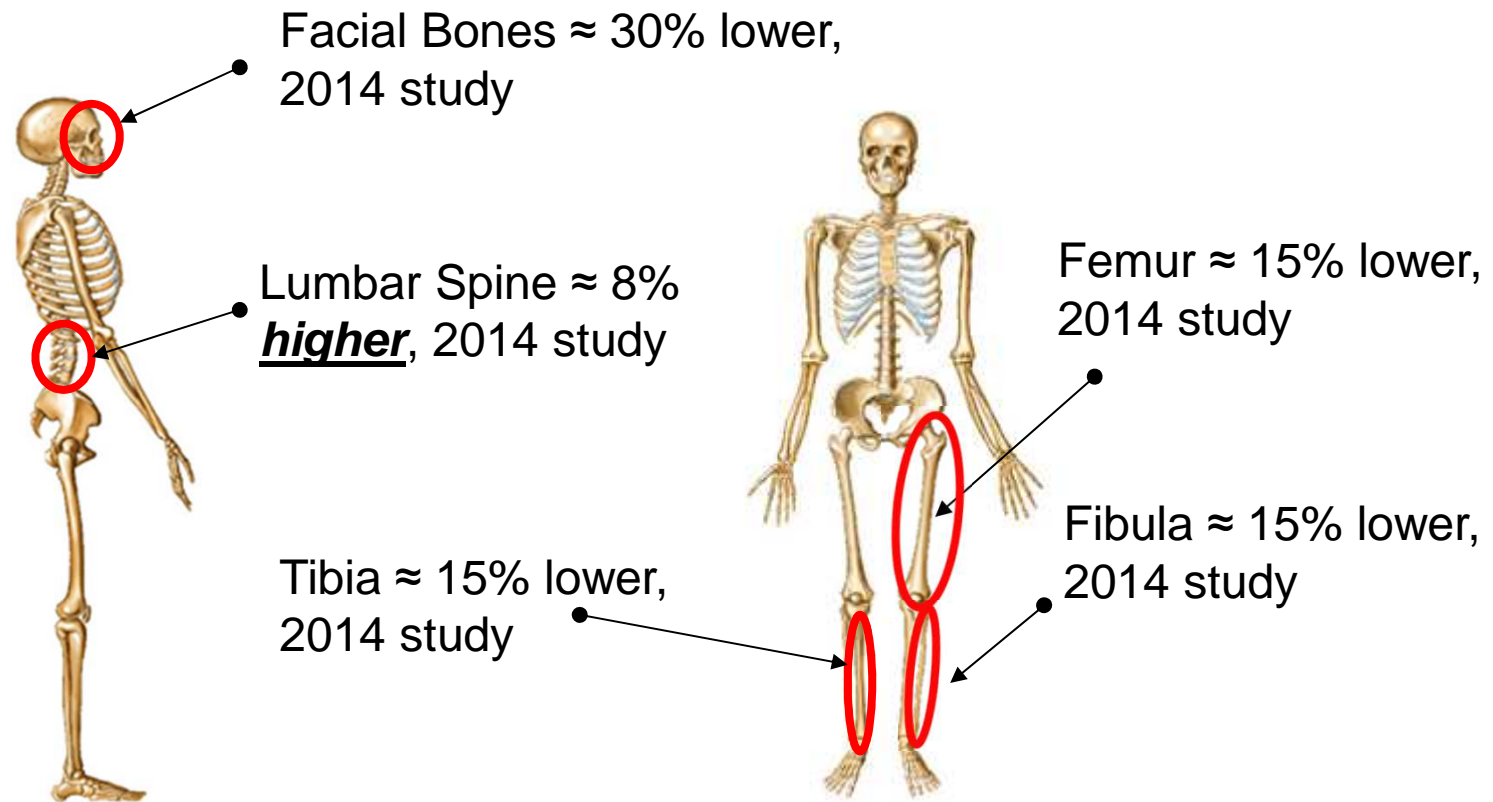
# Bony Injuries



No statistically significant difference in data for bony injuries documented in these areas



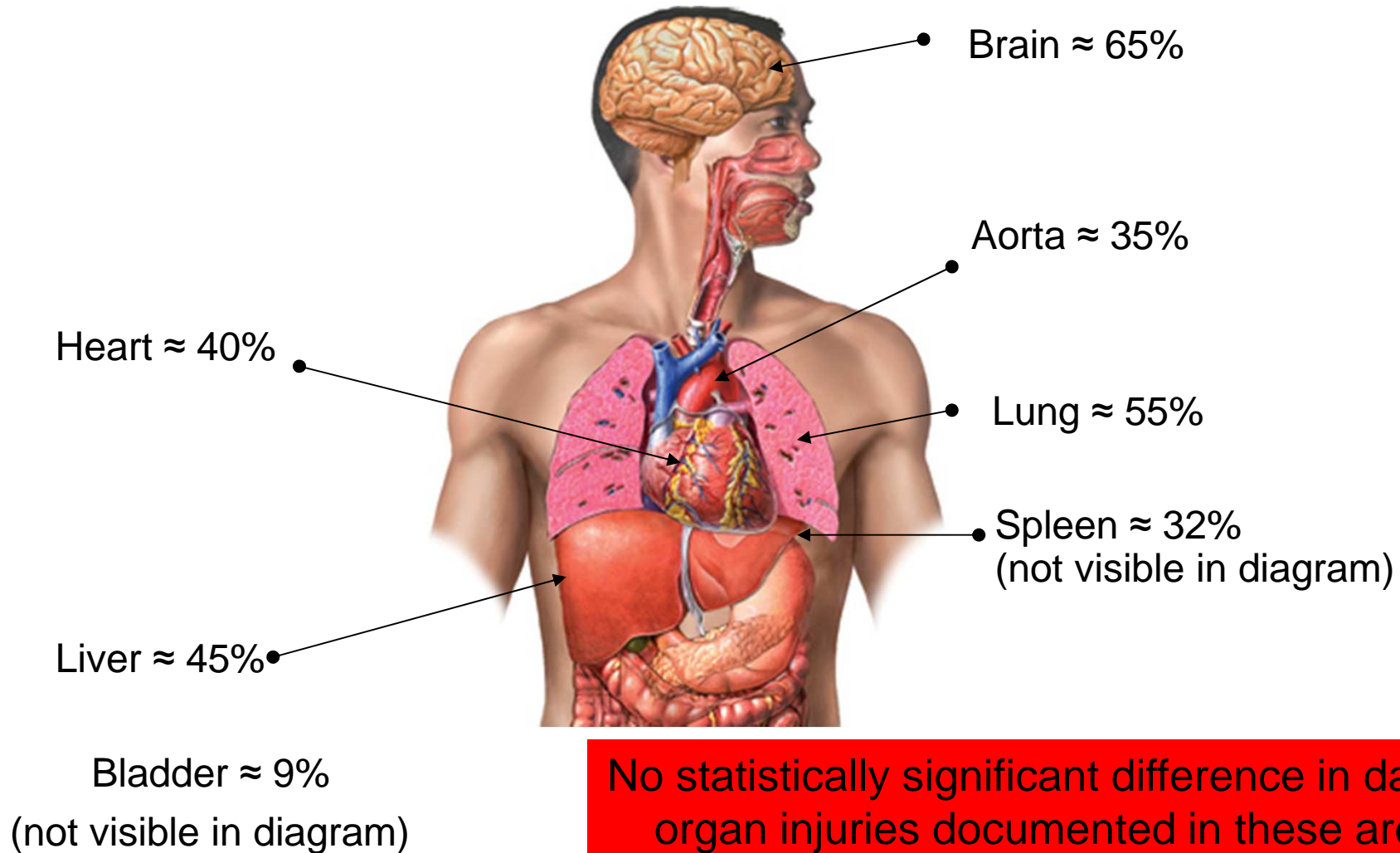
# Bony Injuries



Statistically significant difference in data for bony injuries documented in these areas



# Organ/Visceral Injuries



# Further considerations

- **For the rotorcraft with a certification basis after 2003, were there significant differences in fatal injury patterns?**
  - The Taneja & Wiegmann study was published in 2003.
  - Theoretically, data on fatal injuries patterns could have been applied toward certification efforts after 2003.
- **Answer: A reasonable comparison was not feasible due to a small sample of data with a certification basis after 2003.**
  - Only 2 out of 97 fatal accidents in the study involved rotorcraft with a certification basis after 2003.



# Further considerations (continued)

- **Did significant differences exist for rotorcraft involved in fatal accidents that were compliant with 27.562 or 29.562?**
  - Rules address emergency landing dynamic conditions.
  - Theoretically, compliance may result in different fatal injury patterns.
- **Answer: A reasonable comparison was not feasible due to only a small sample of data complying with 27.562 or 29.562.**
  - Only 5 of 97 (5%) of rotorcraft in the data set complied.
- **The sample was found to be representative of low overall compliance for the U.S. registered rotorcraft population.**
  - About 10% compliance with 27.562 or 29.562 as of 2014.
  - Rule effective in November, 1989.



# Further considerations (continued)

- **Could analysis by date manufactured be accomplished?**
  - Yes: Feasible, but provides much less valuable information.
  - Even if manufactured after 2003, may still have a certification basis date many years (perhaps decades) prior to 2003.
- **Divided the fatal accident data from 2008-2013 into two groups**
  - 1) Rotorcraft manufactured in 2003 or prior to 2003
  - 2) Rotorcraft manufactured after 2003
- **Compared each group to Taneja & Wiegmann study**
  - No significant difference for either group across nearly all injury categories.
- **Compared each group against each other**
  - No significant difference from each other across any injury category.



# Blunt Force Injury Study Summary

- **10 years after the Taneja and Wiegmann study...**
  - No statistically significant difference for most documented bony injuries and organ/visceral injuries in fatal U.S. rotorcraft accidents.
- **Next Steps**
  - What improvements to crashworthiness or survivability equipment can decrease injuries and reduce fatal accidents? Are any possible for retrofit?
  - Which ones should be emphasized, actively pursued, or identified for regulatory activity?





# Project Contributors

## Rotorcraft Directorate

- **Rotorcraft Standards Staff**
  - Tyrone Millard
- **Safety Management Group**
  - Jim Grigg
  - Lee Roskop

## CAMI

- **Medical Case Research Physician**
  - Dr. G.J. Salazar
  - Dr. Nicholas Webster
- **CAMI Autopsy Program Team**
  - Ms. Christy Hileman
  - Ms. Cheryl McNeil
- **CAMI Biostatistician**
  - Dr. Valerie Skaggs

