



# Comparison of Development of Heterotopic Ossification Between Injured US and UK Armed Service Personnel with Combat-Related Amputations



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# Background

- Heterotopic ossification = formation of bone outside skeletal system
- Pathogenesis<sup>1,2</sup>:
  - Inciting event
  - Signal
  - Mesenchymal cells
  - Supportive environment



1. Hunt JL, Arnaldo BD, Kowalske K, et al. Heterotopic ossification revisited: A 21-year surgical experience. *J Burn Care Res* 2006;27(4):535-40.

2. McCarthy EF, Sundaram M. Heterotopic ossification: A review. *Skeletal Radiol* 2005, Oct;34(10):609-19.

# Background

- Historical reports<sup>3,4</sup>
- Complications
  - Limb pain
  - Bony spicules
  - Infection
- Rehabilitation
  - Prostheses
  - Joint movements



3. Otis GA, Huntington DL. Wounds and complications. In: Barnes JK, editor. *The medical and surgical history of the Civil War*. Vol 2, pt 3. Washington, DC: Government Printing Office; 1883. p 880.

4. Brackett EG. Care of the amputated in the United States. In: Ireland MW, editor. *The medical department of the United States Army in the World War*. Vol 11, pt 1. Washington, DC: Government Printing Office; 1927. p 713-48.

# Background

- Recent study: US military personnel<sup>5</sup>
  - possible association to injury from explosive missiles
- Aetiology:
  - i. Development HO
    - i. Amputation in ZOI
    - ii. Blast
  - ii. Severity HO
    - i. Number procedures
    - ii. Time to closure



5. Potter BK, Burns TC, Lacap AP, et al. Heterotopic ossification in the residual limbs of traumatic and combat-related amputees. *J Am Acad Orthop Surg* 2006;14(10 Spec No.):S191-7.

# Hypotheses



- 1) There are differences in the rate of HO between the UK and US combat related amputee populations



# Hypotheses



2) There are differences in practice in the management of amputees between the UK and US Allied Forces



# Hypotheses

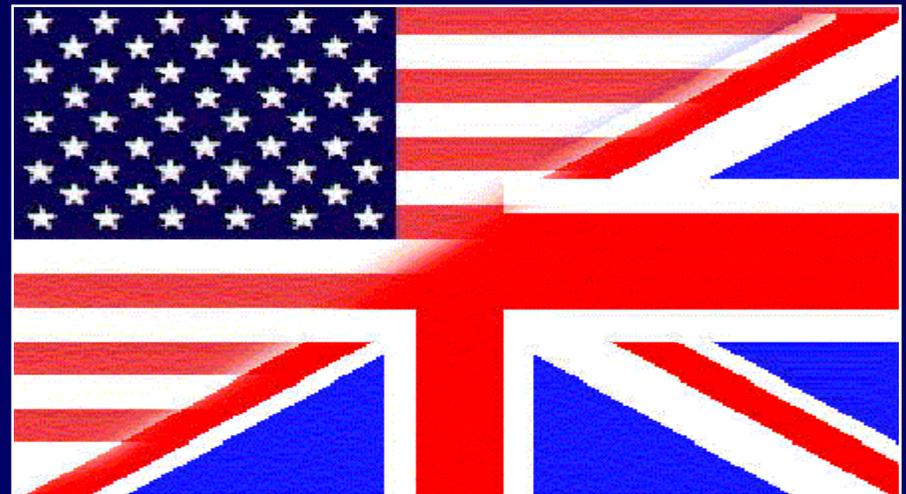


3) These differences in practice may affect the rate and severity of HO in these patients.



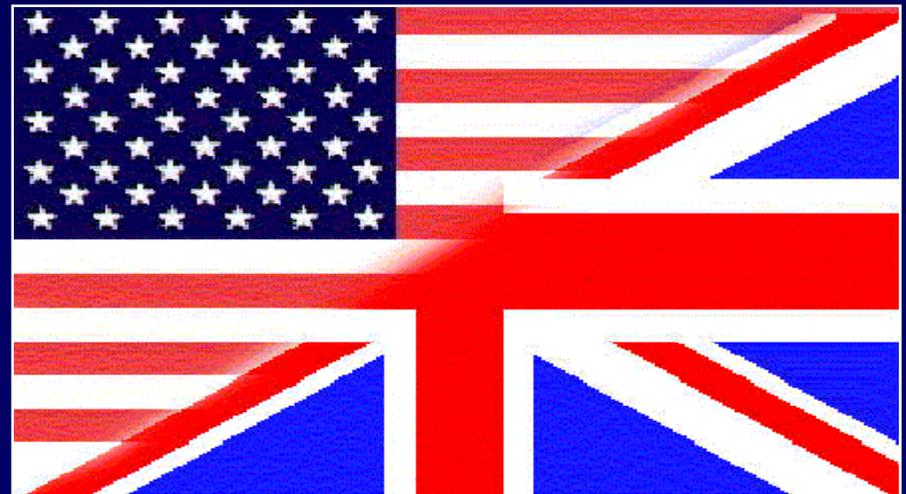
# Methods

- Retrospective study of wounded service members (GWOT, Aug 03-07):
  - UK (Group 1)
  - US (Group 2)
- JTTR and designated centres
- Demographics:
  - Age
  - Sex
  - MOI/ZOI
  - Timings of injury
  - ISS



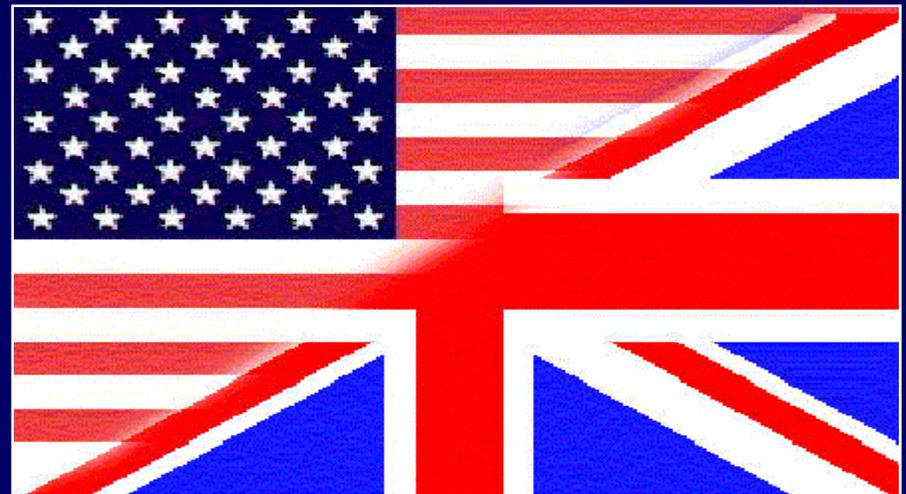
# Methods

- Data:
  - Specific patterns of injury
  - Number of debridements
  - Number of days to closure
  - Type of closure
- Radiographs
- Direct comparisons:
  - Prevalence HO
  - MOI
  - Treatment modalities



# Methods

- Statistics
  - i. Chi-squared analysis
  - ii. Fisher's Exact and student t-test
  - iii. Regression analysis
- Significance:  $p < 0.05$



# Methods

## Grading of HO

1. None: no soft-tissue mineralization evident on radiographs made at least two months after the injury



# Methods

## Grading of HO

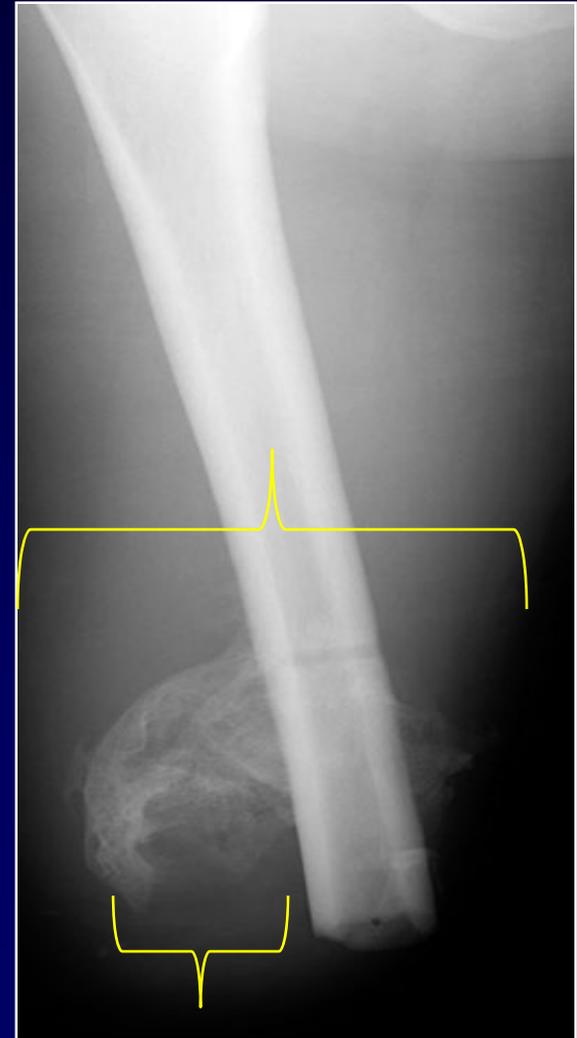
2. Mild: ectopic bone occupied an estimated <math><25\%</math> of the cross-sectional area of the residual limb on either the anteroposterior or lateral radiograph



# Methods

## Grading of HO

3. Moderate HO: occupied 25% to 50% of the cross-sectional area of the residual limb on either the anteroposterior or lateral radiograph



# Methods

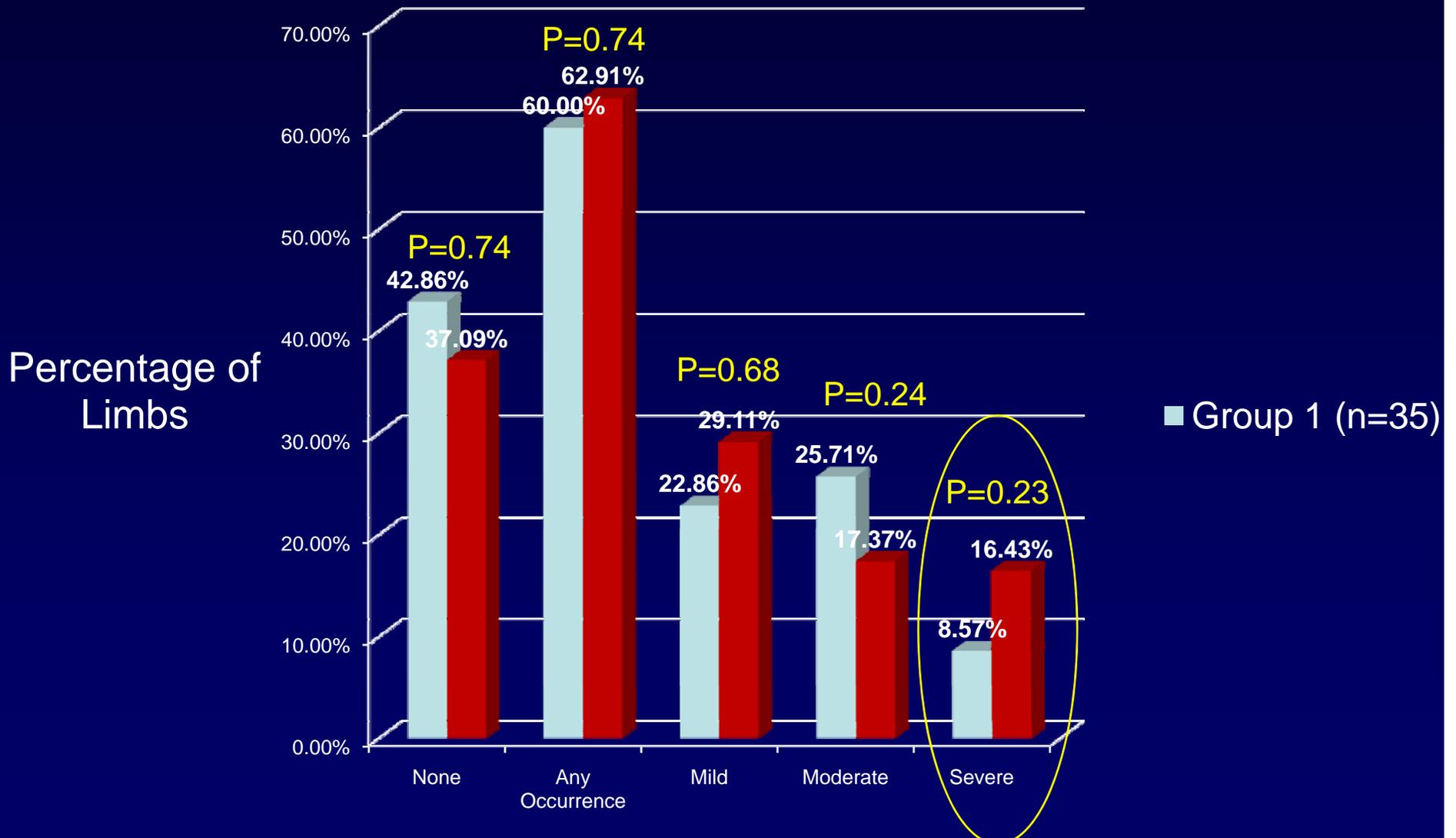
## Grading of HO

4. Severe HO: occupied >50% of the cross-sectional area of the residual limb on either the anteroposterior or lateral radiograph



# Results

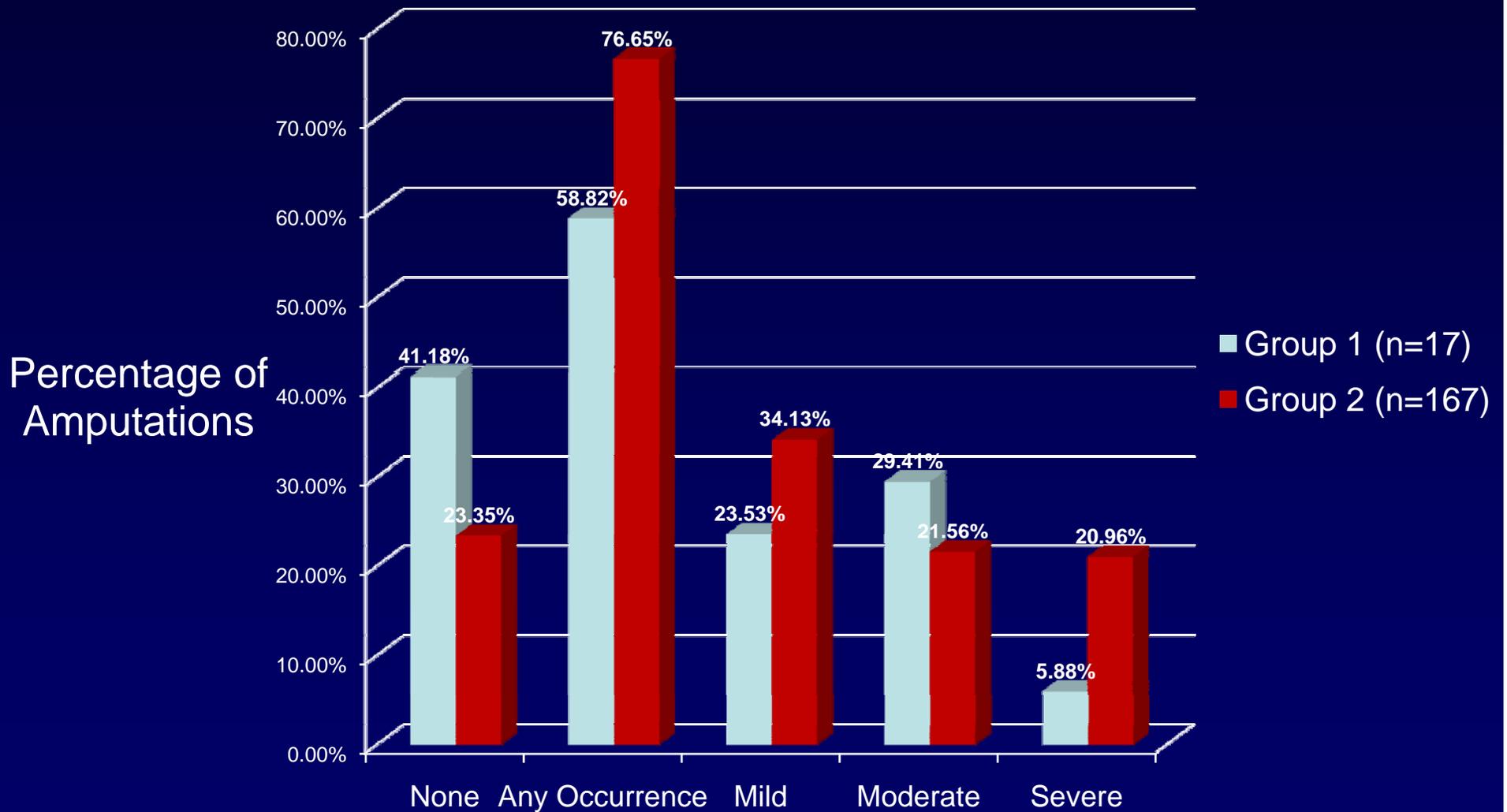
## Overall prevalence HO



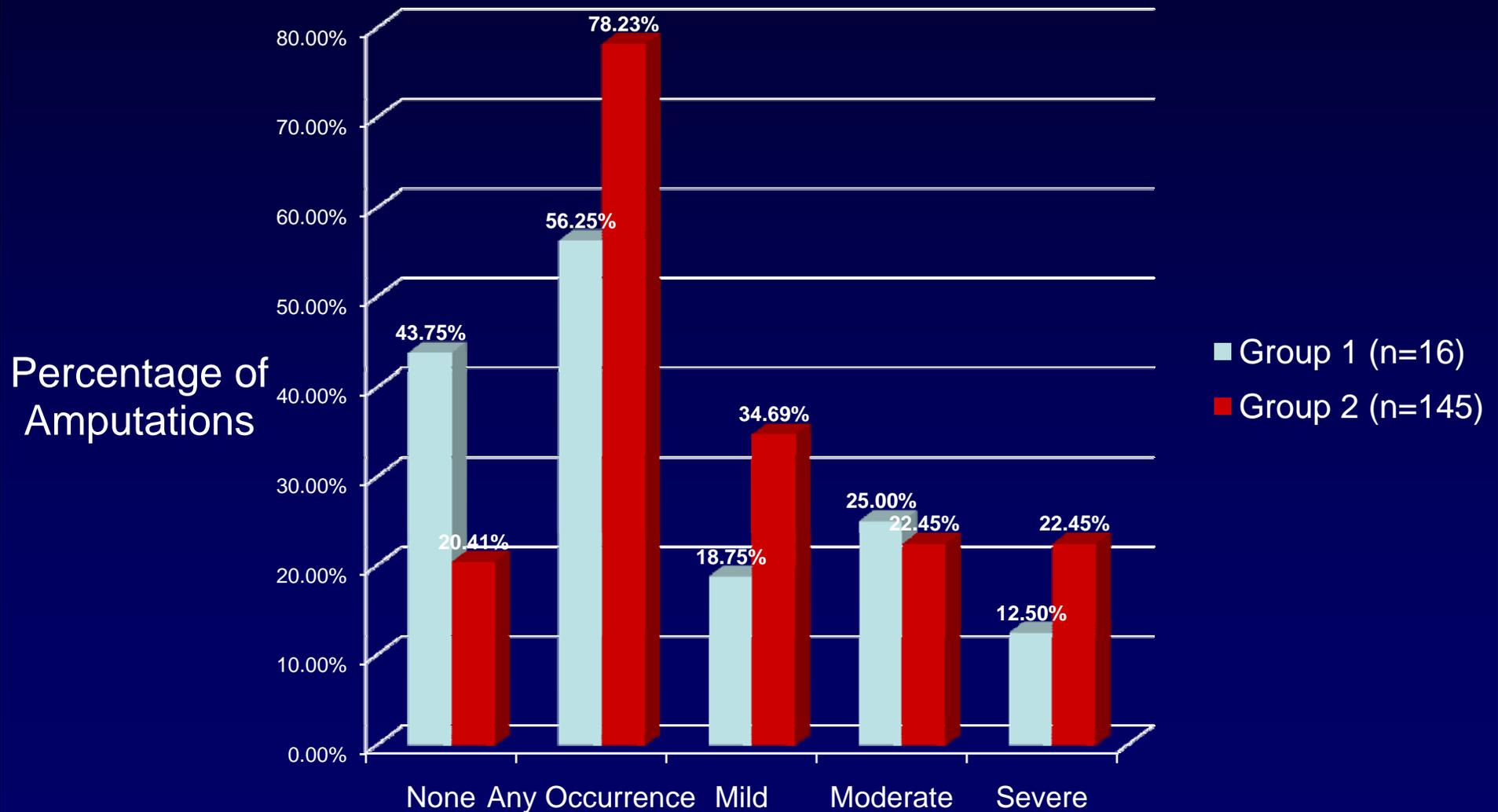
# Results

|   |           | Group 1<br>(n=35) | Group 2<br>(n=213) | p value                      |
|---|-----------|-------------------|--------------------|------------------------------|
| <b>MOI</b>                                | Blast     | 33 (94.29%)       | 187 (87.79%)       | 0.39                         |
|   | Non Blast | 2 (5.71%)         | 26 (12.21%)        |                              |
| <b>Amputation</b>                         | In ZOI    | 17 (48.57%)       | 166 (77.93%)       | <b>0.0003<sup>***</sup></b>  |
|   | Above ZOI | 18 (51.43%)       | 47 (22.07%)        |                              |
| <b>Amputation Due to Blast Injury</b>     | In ZOI    | 16 (45.71%)       | 145 (68.08%)       | <b>0.0004<sup>***</sup></b>  |
|   | Above ZOI | 17 (45.57%)       | 41 (19.25%)        |                              |
| <b>Amputation Due to Non-Blast Injury</b> | In ZOI    | 1 (2.86%)         | 21 (9.86%)         | 0.43                         |
|   | Above ZOI | 1 (2.86%)         | 6 (2.82%)          |                              |
| <b>No. of I+Ds</b>                        | Mean      | 4.06              | 6.46               | <b>0.00003<sup>***</sup></b> |
|   | Median    | 4                 | 6                  |                              |
|   | Range     | 1-9               | 2-20               |                              |
| <b>No. of days closure</b>                | Mean      | 14.49             | 17.33              | <b>0.007<sup>***</sup></b>   |
|   | Median    | 9                 | 15                 |                              |
|   | Range     | 2-57              | 4-57               |                              |
| <b>Method of closure</b>                  | Direct    | 18 (51.43%)       | 149 (70%)          | <b>0.03<sup>***</sup></b>    |
|   | SSG/Flap  | 17 (48.57%)       | 64 (30.05%)        |                              |
|   | absent    | 19 (54.29%)       | 0 (0%)             |                              |

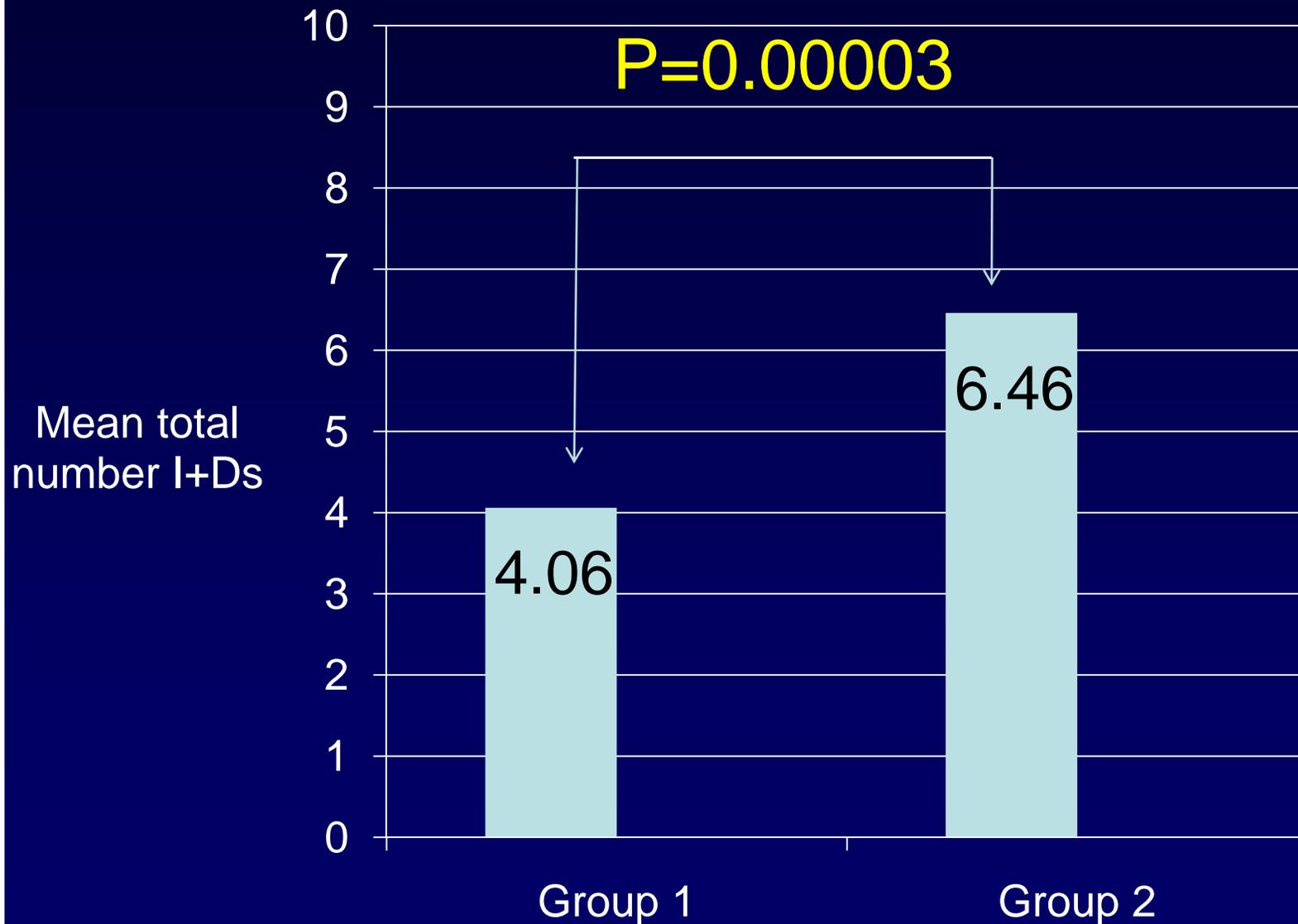
# Amputations In ZOI (P=0.003)



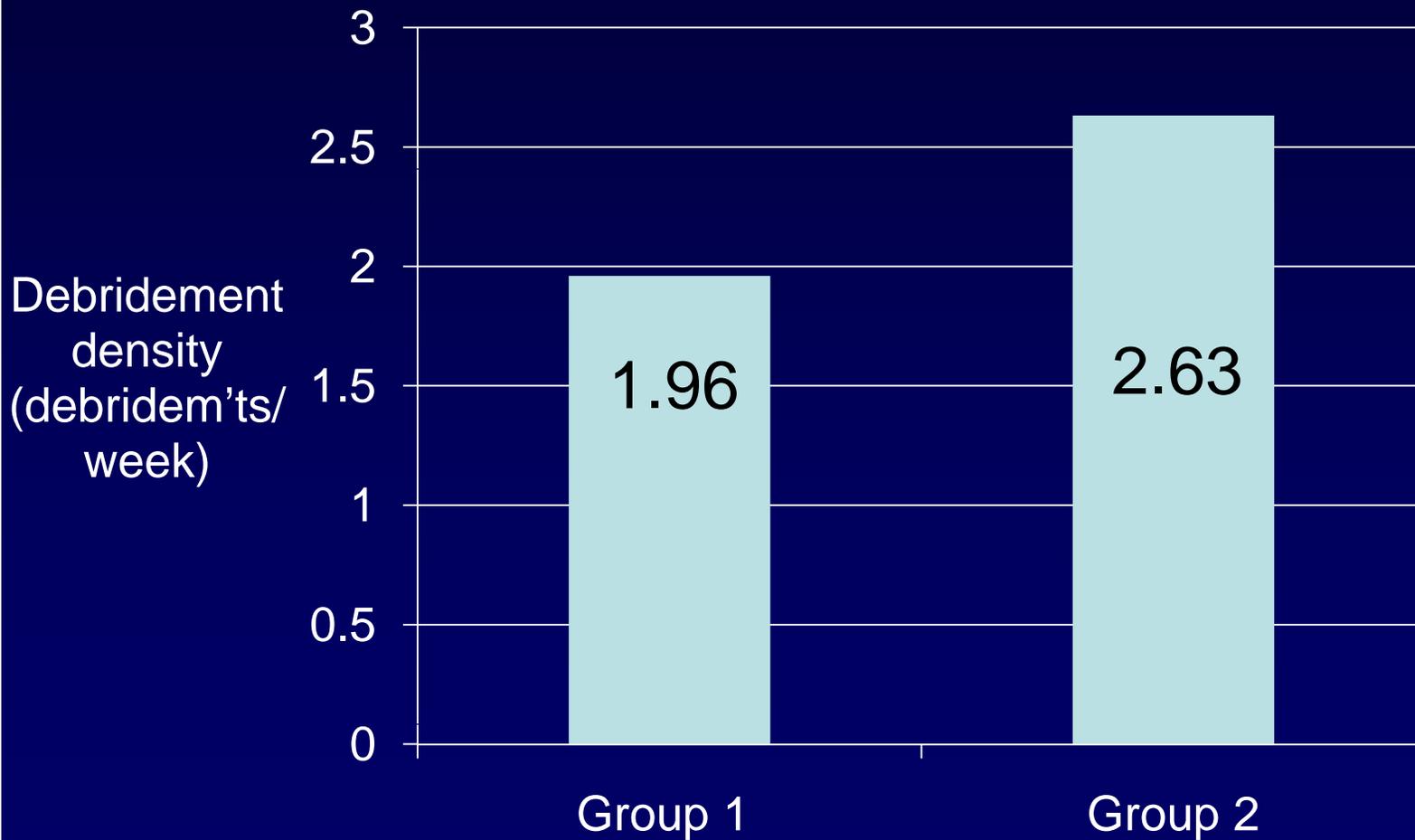
# Amputations Due to Blast Injuries In ZOI (P=0.0004)



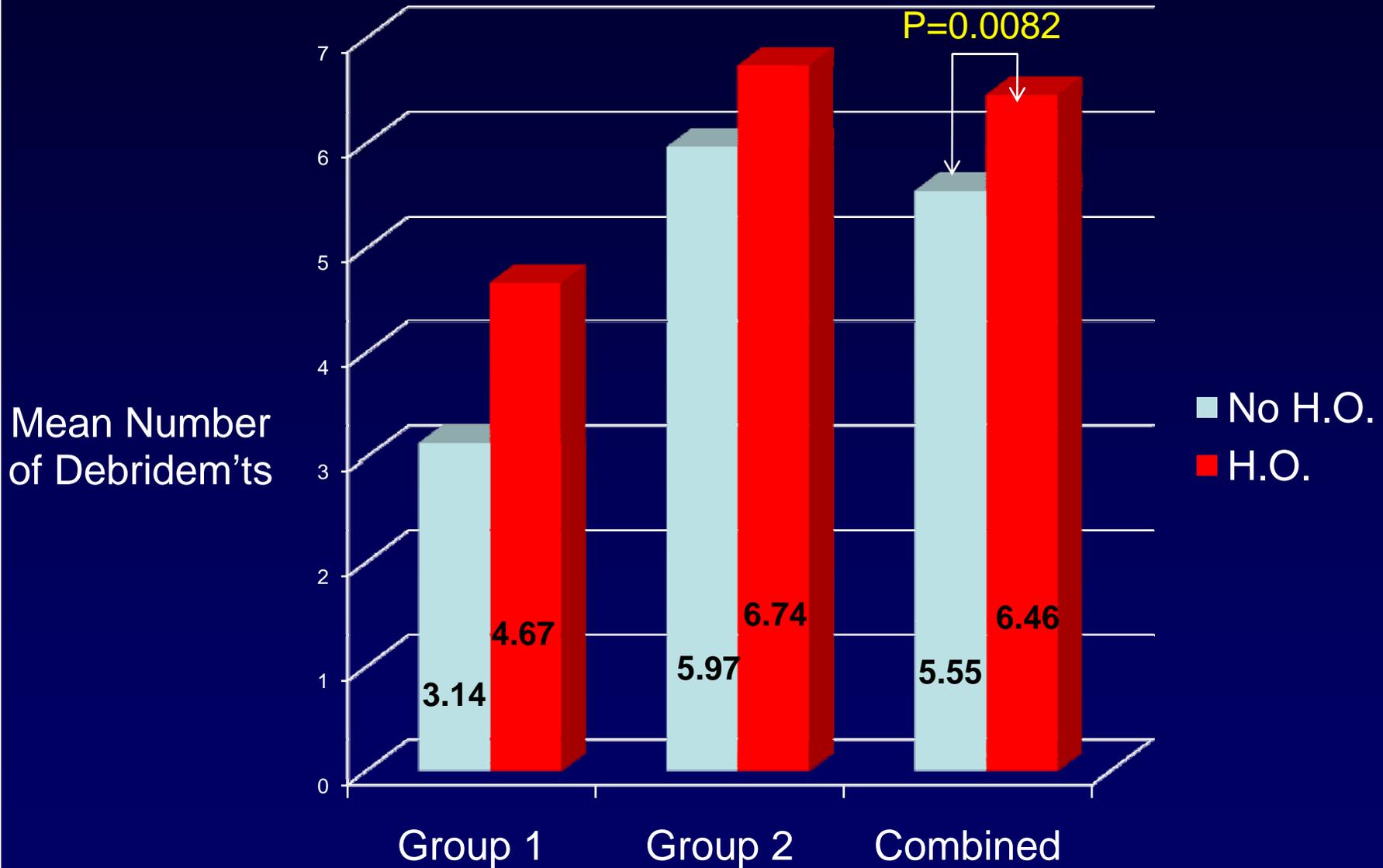
# Irrigation and Debridements



# Debridement density

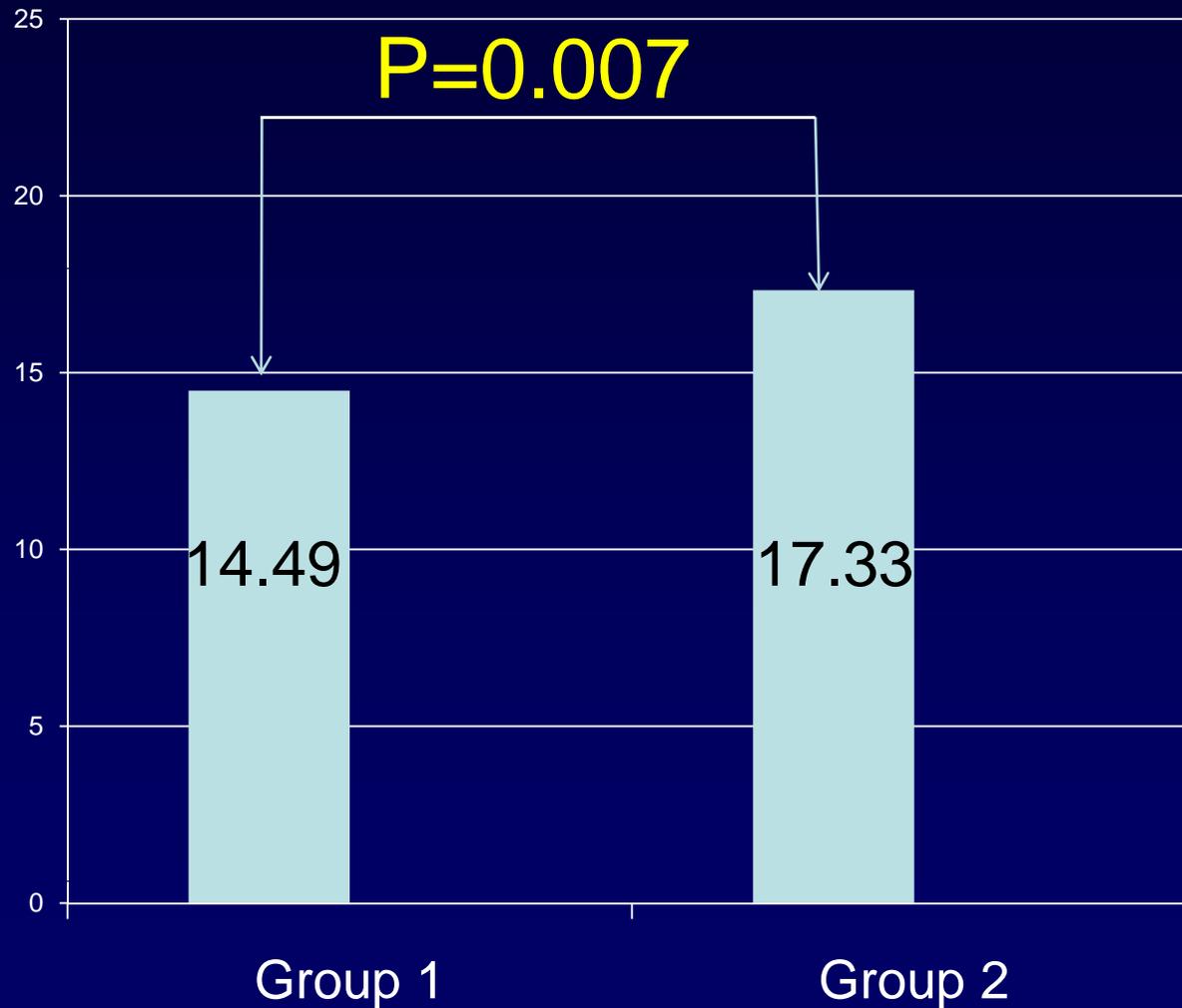


# Number of Debridements

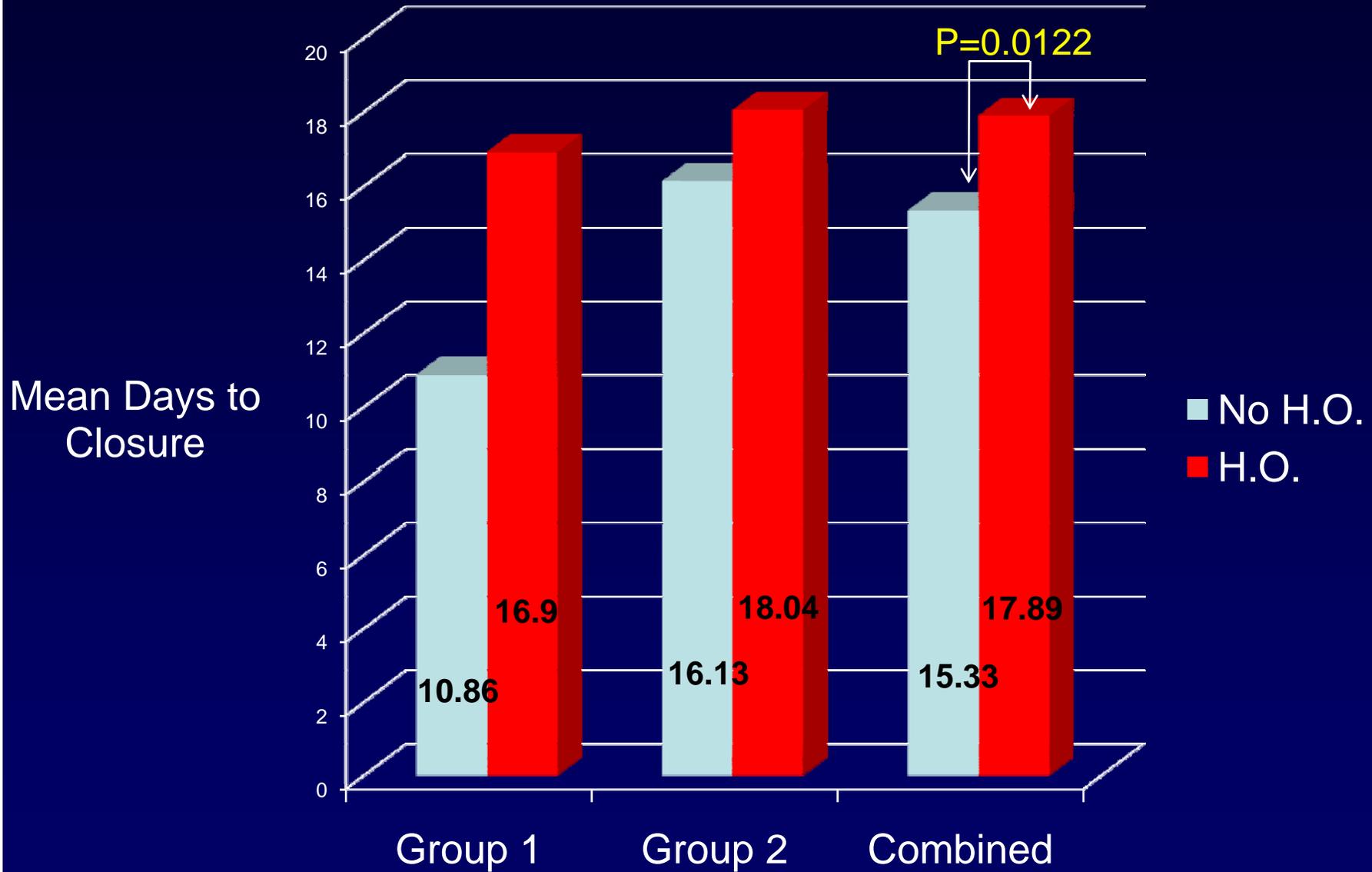


# Days to Closure

Mean total  
number of  
days to  
closure



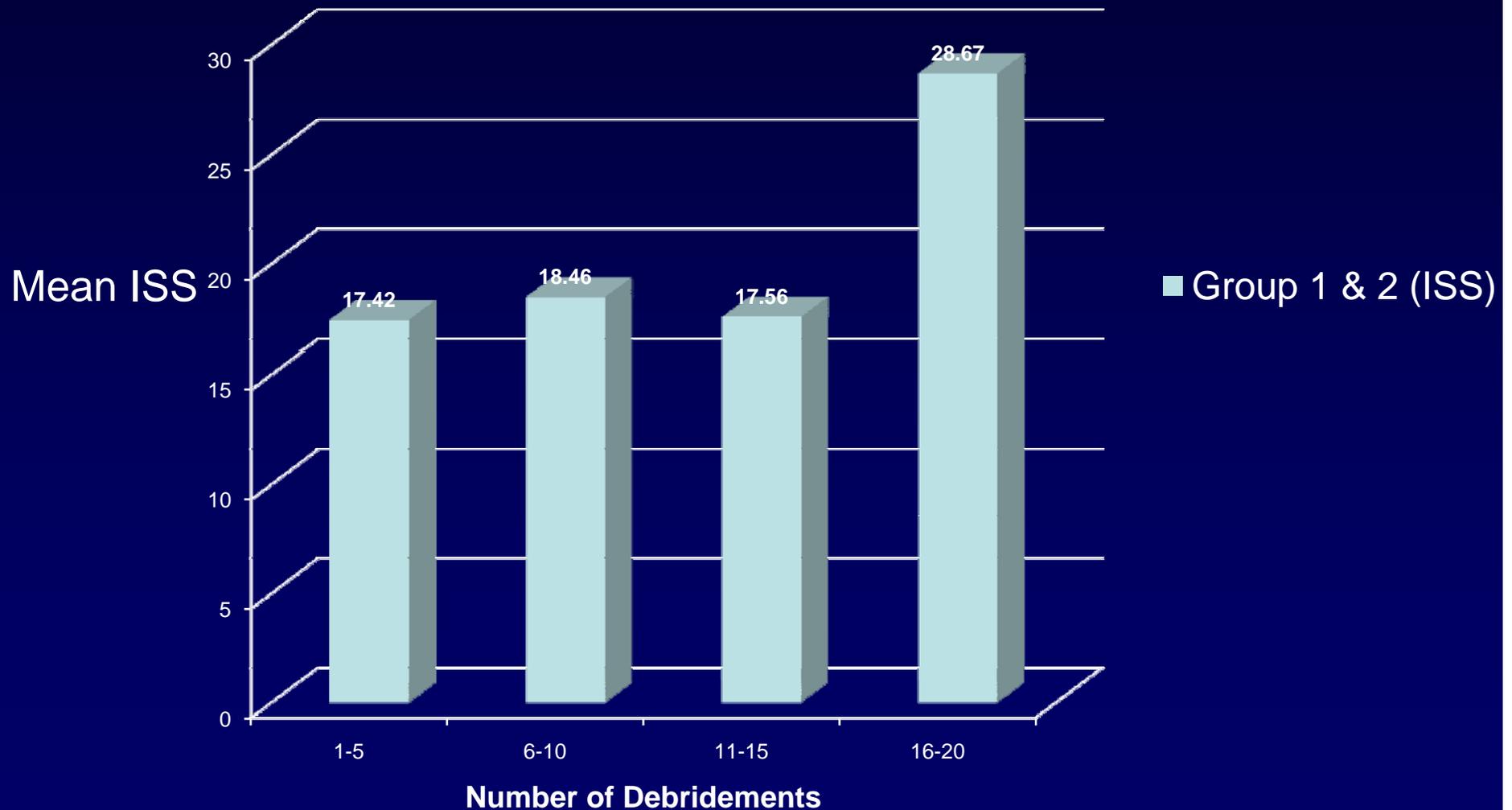
# Number Days to Closure



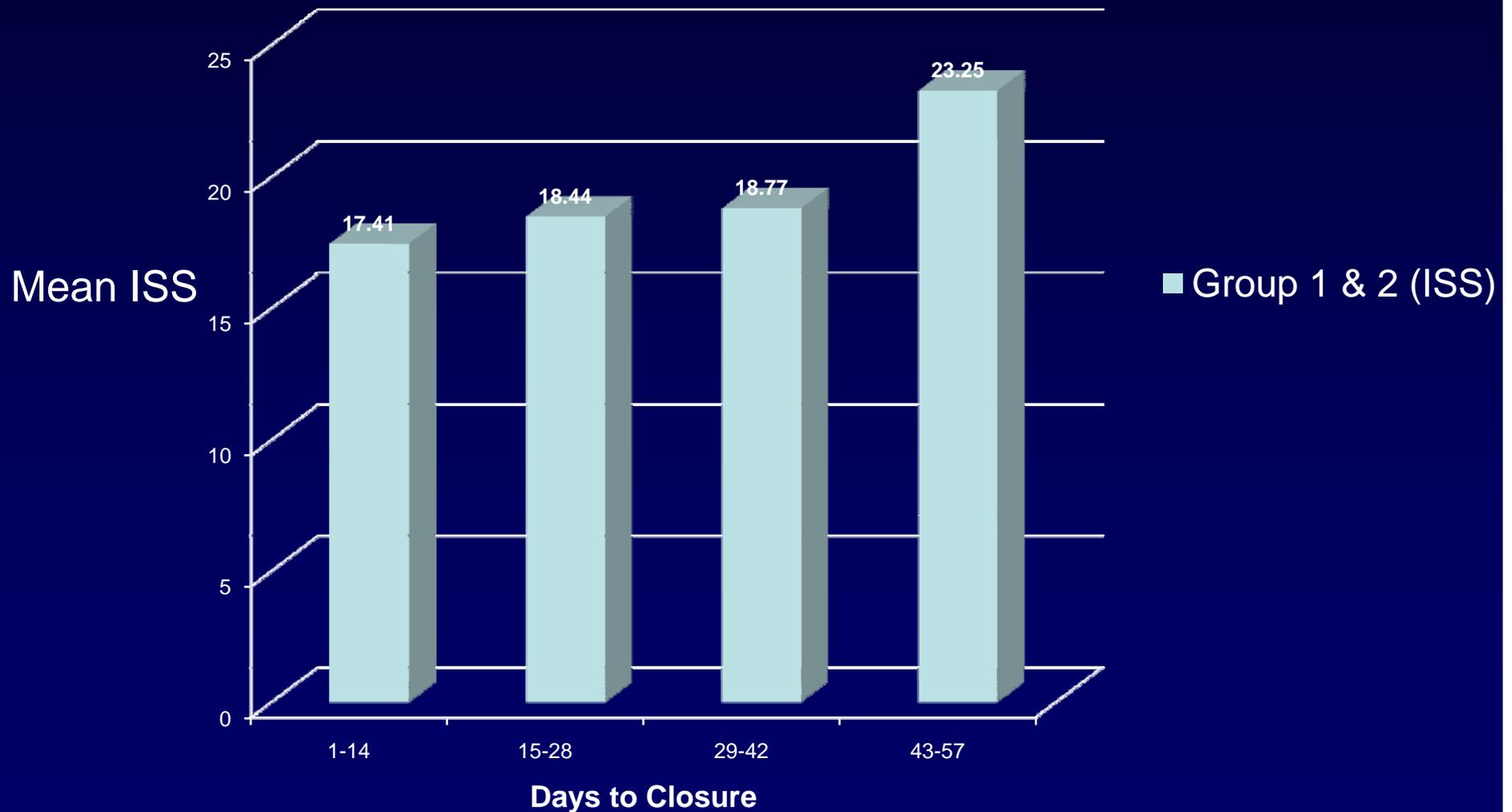
# Injury Severity Score

|     | HO     | None  | Mild  | Mod   | Severe | None vs Any     | None/Mild vs Mod/Severe |
|-----|--------|-------|-------|-------|--------|-----------------|-------------------------|
| ISS | Mean   | 19.2  | 16.75 | 37.67 | 36.3   | <b>0.041***</b> | <b>0.0062***</b>        |
|     | Median | 17    | 20    | 42    | 42     |                 |                         |
|     | Range  | 13-45 | 5-41  | 14-59 | 25-42  |                 |                         |

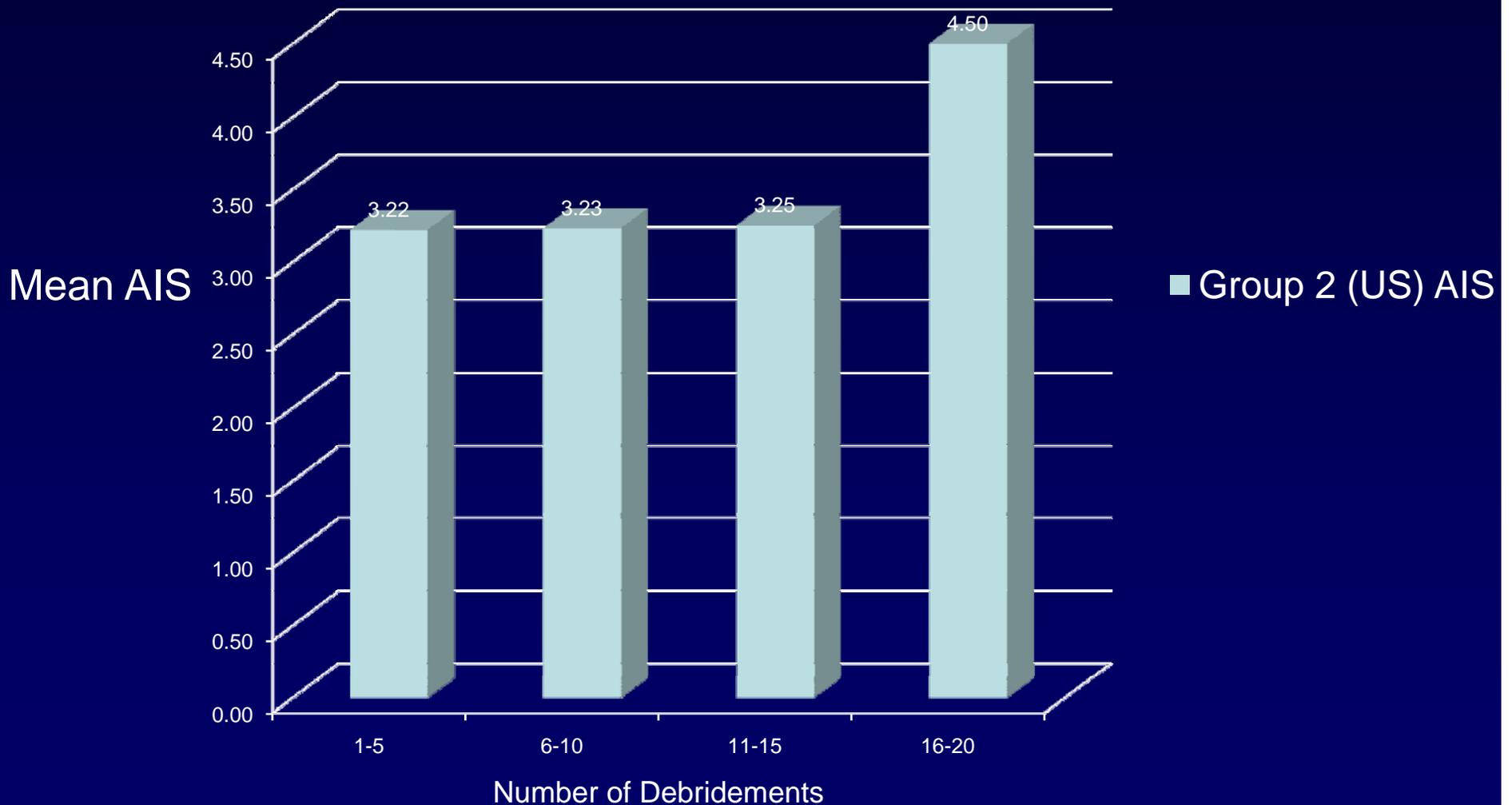
# Association between ISS and Number of Debridements ( $P=0.7894$ )



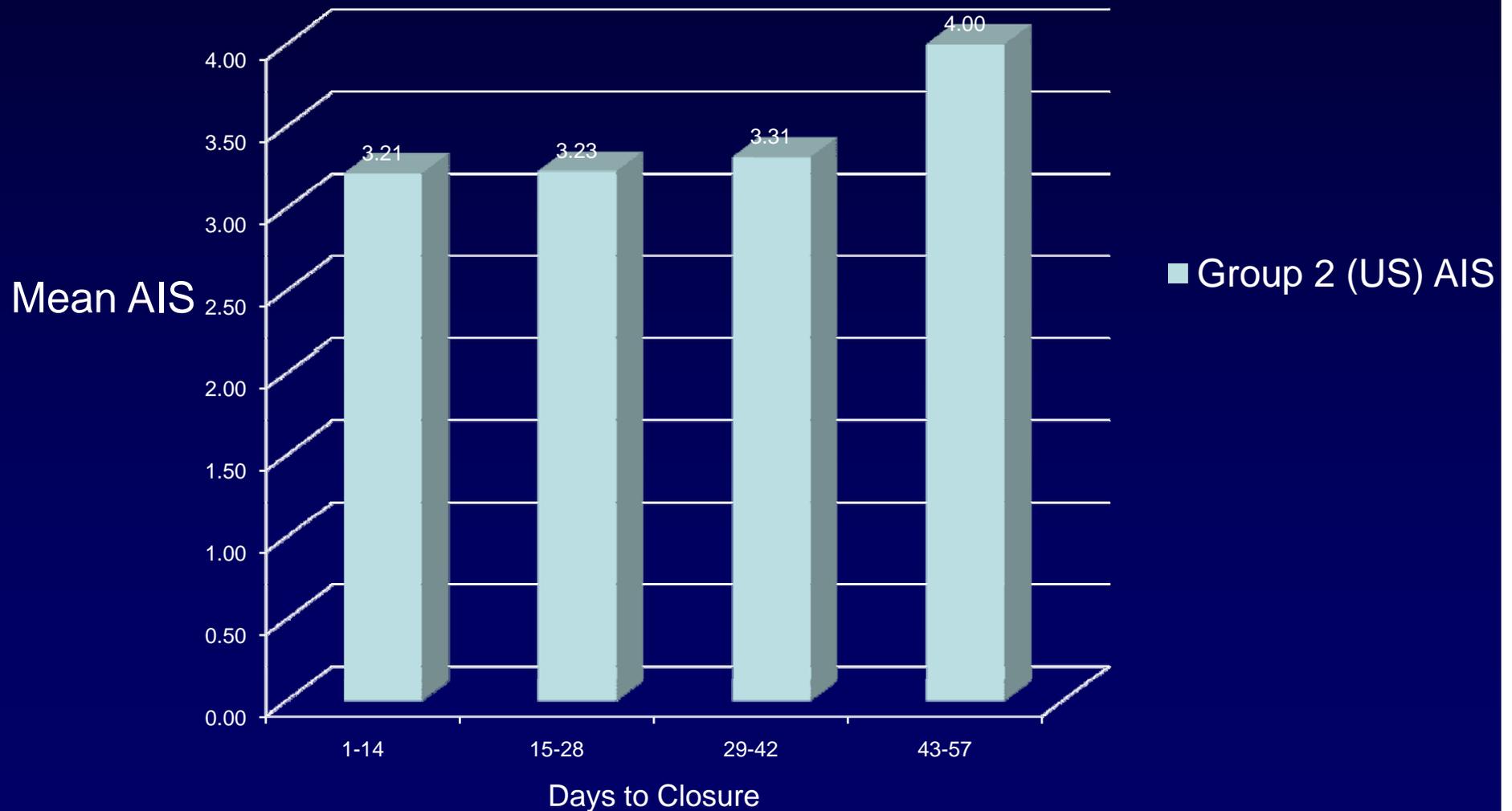
# Association between ISS and Time to Closure ( $P=0.6287$ )



# Association Between Extremity AIS and Number of Debridements ( $p=0.2455$ )



# Association Between AIS and Time to Closure ( $p=0.2656$ )

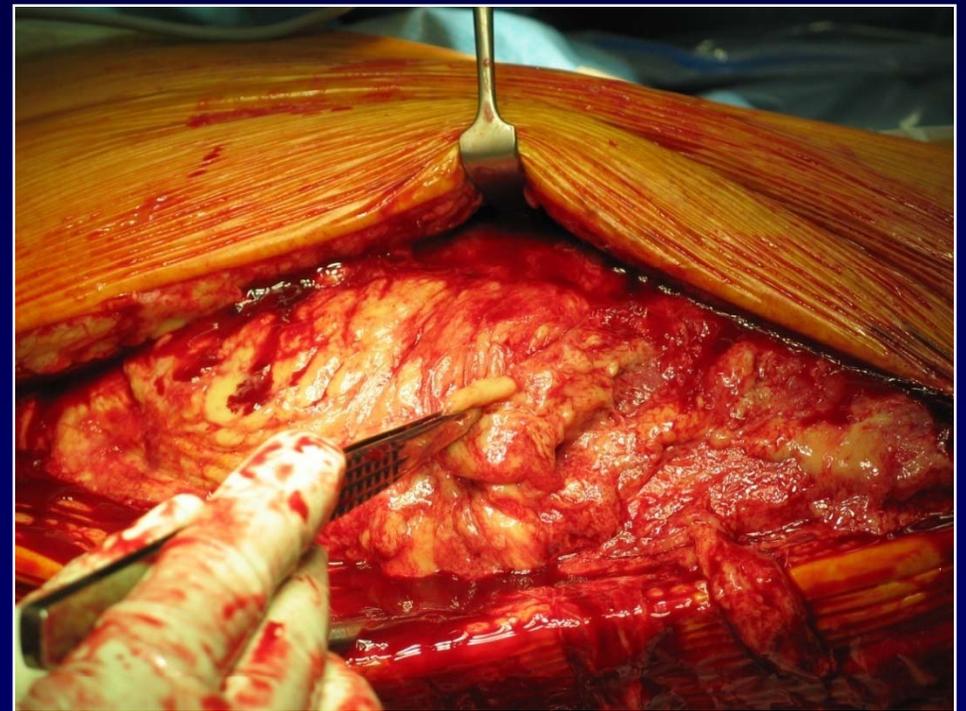




# Discussion



- Confirmed association between HO and
  - i. Blast injury
  - ii. Amputation in ZOI
- Found association between HO and
  - i. Increasing ISS
  - ii. Increasing number of debridements
  - iii. Increasing number of days to closure



# Limitations

- Retrospective
- Difficult to define severity of limb injury
- Group 1 small numbers
- Unable to clarify in Group 2:
  - Treatment with NPWT
  - Treatment with pulsatile lavage
- Length of follow-up
- Classification of HO not yet validated

# Conclusions



- 1) There are differences in the rate of HO between the UK and US combat related amputee populations
  - Severe HO



# Conclusions



- 2) There are differences in practice in the management of amputees between the UK and US Allied Forces
- Particularly in the number of surgical debridements



# Conclusions



- 3) These differences in practice may affect the rate and severity of HO in these patients.
- Not confirmed





# Future directions



- Successful collaboration
- Review of surgical treatment modalities
- Management of systemic metabolic response
- Validate classification system



# Thankyou

## Questions

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