Compartment Syndrome Complications in Pediatric Patients

* **What is Compartment Syndrome?**
  + Notes (1 min)
    - Compartment syndrome refers to the increased pressure inside the section of the limb that contains muscles, nerves, and blood vessels.
    - This increased pressure results in the reduction of blood supply and tissue necrosis.
    - It usually develops in the lower leg and forearm after traumas like a bone fracture.
      * If not treated in time, it can lead to permanent muscle and nerve damage.
  + Play Video (3:40)
* **When does Compartment Syndrome Occur?**
  + Notes
    - Compartment Syndrome typically develops after surgery or trauma,
      * Causing excessive fluid in the fascia, causing pressure and pain in the affected limb.
    - The decreased circulation causes the muscle can die, resulting in permanent damage left untreated.
  + Play Video (60 seconds)
* **How is Compartment Syndrome Treated?**
  + Notes
    - Treatment of compartment syndrome is a fasciotomy or removal of external compression, which can relieve the pressure and maintains blood flow to the muscle.
  + Play Video (160 seconds)
* **Review of Compartment Syndrome and Fasciotomy**
  + Notes
    - In this study, we will use Fasciotomy as the indicator for Compartment Syndrome
    - We did this for the following reasons:
      * Compartment Syndrome is a diagnosis that is subject to human error
      * The PTOS results are sparse in terms of date, time, and accuracy of diagnosis
      * Fasciotomy is a procedure that takes place because of Compartment Syndrome
      * This is a surgical procedure and it is well documented in the PTOS data
* **Forearm Fractures**

1. Open Reduction with Internal Fixation
   1. Open reduction with internal fixation is a surgical reduction of a [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm).
   2. A surgical incision is made to expose the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) site.
   3. The bone ends or fragments are then aligned and secured by an internal fixation device.
   4. Numerous internal fixation devices are used including nails, pins, screws, plates, wires and rods.
   5. Even for stable or non-displaced fractures, [open reduction](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/O/glo_Open_reduction.htm) is often preferred when fractures of long bones are involved.
   6. <https://lnav.iso.com/medicallibrary_icd10/Medical_Library/Upper_and_Lower_Extremity_Medical_and_Diagnostic_Procedures/Bones/Open_Reduction_with_Internal_Fixation.htm>
2. Closed Reduction without Internal Fixation
   1. Closed reduction of a [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) is done by manipulation, with or without general anesthetic.
   2. The surgeon manually manipulates the broken ends back into anatomical alignment.
   3. This is not a surgical procedure, as opposed to [open reduction](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/O/glo_Open_reduction.htm), which is surgical.
   4. Non-displaced and stable fractures are generally treated by [closed reduction](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/C/glo_Closed_Reduction.htm) methods.
   5. The procedure will normally be described as "closed reduction".
   6. Once the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) is reduced it will be held with an immobilization device such as a plaster cast or splint.
   7. In some upper extremity fractures, the limb will simply be placed in a sling.
   8. <https://lnav.iso.com/medicallibrary_icd10/Medical_Library/Upper_and_Lower_Extremity_Medical_and_Diagnostic_Procedures/Bones/Closed_Reduction_without_Internal_Fixation.htm>
3. Closed Reduction with Internal Fixation
   1. The codes for this procedure are to be used when the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) is treated by [percutaneous](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/P/glo_Percutaneous.htm) insertion of an internal fixator such as a nail.
   2. Most internal fixation devices are inserted after open surgery to expose the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) site, but some fractures can be treated by making a small incision and inserting a nail.
   3. This is known as a [percutaneous](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/P/glo_Percutaneous.htm) internal fixation.
   4. The [femur](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Femur.htm), in particular, is treated this way.
   5. Percutaneous intramedullary nailing is sometimes used to treat femoral shaft fractures.
4. Open Reduction without Internal Fixation
   1. The term [open reduction](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/O/glo_Open_reduction.htm) means surgical reduction.
   2. The [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) site is opened surgically and exposed so as to reduce the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm).
   3. Open reduction is performed when a [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) cannot be reduced manually by manipulation or when it is unstable, grossly displaced or fragmented.
   4. In most cases, [open reduction](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/O/glo_Open_reduction.htm) is performed with internal fixation of the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) fragments, but these codes are only to be used when the [fracture](https://lnav.iso.com/medicallibrary_icd10/Medical_Glossary/F/glo_Fracture.htm) is not secured by an internal fixator.

* Objective of Compartment Syndrome Analysis
  + Identify the likelihood of compartment syndrome in pediatric patients who suffered from forearm fractures.
* Data Preparation
  + traumaR
    - PTOS Data consists of 530k anonymized patient records and 1,400 columns
      * Columns mostly consisting of medical codes which required translation
      * Necessary to normalize the data into structured data frame
    - Developed a custom package to translate all medical codes into human friendly terms
      * Wrote over 50 functions to automate this work and make it repeatable
    - The final results create two main data frames joined together by patient\_id
      * Patient Information
      * Medical Procedures
* Exploratory Data Analysis
  + Patient Demographics
  + Forearm Fractures
  + Fasciotomy
  + Compartment Syndrome Diagnosis vs. Fasciotomy
  + Fasciotomy vs. Forearm Fractures
  + Fasciotomy Results by Forearm Fractures by Adults and Pediatrics
* Predicting Fasciotomy: Modeling
  + Model Explanation
    - Target: Fasciotomy: TRUE or FALSE
    - Predictors:
      * Sex
      * Race
      * Age in Years
      * Surgical Procedure Description
      * Cause of Injury
      * Place of Injury
  + Model Pre-Processing
    - Class Imbalance
      * Show Graph for Class Imbalance
        + Used ROSE to balance Train Data
        + Initial models were memorizing and returning a 3% accuracy
    - Feature Engineering
      * Used recipes from TidyModels (get hex sticker)
      * Step Other
        + Groups categorical information into ‘other’ category whose individual levels do not exceed preset threshold.
      * Step Dummy
        + Converts character or factors into dummy variables
      * Step Zero Variance
        + Removes variables that contain only a single value

This is a precautionary step to ensure that Step Other captured all low occurrence into ‘Other’

* + - * Step Omit NA
        + Remove any observations with missing values

Some models cannot handle missing values

* + Model Results
    - Logistic Regression
    - Ridge Regression
    - RandomForest: Ranger
    - XGBoost
    - Neural Network
  + Model Accuracy
    - Results
      * In-sample
      * Out-of-sample
    - Variable Importance
    - Overview of Rules from RandomForest
* Association Analysis
  + Market Basket Analysis on Surgical Procedure Results
* Results

# 79.32 - Open reduction of fracture with internal fixation (12K)

<https://www.youtube.com/watch?v=DHc47p4owH8>

# 79.02 - Closed reduction of fracture without internal fixation (7K)

<https://www.youtube.com/watch?v=cy6f7he2e4w>

<https://lnav.iso.com/medicallibrary_icd10/Medical_Library/Upper_and_Lower_Extremity_Medical_and_Diagnostic_Procedures/Bones/Closed_Reduction_without_Internal_Fixation.htm>

* Painful for the patient
* Cast or splint required

# 79.12 - Closed reduction of fracture with internal fixation (1.5K)

<http://www.posnacademy.org/media/Closed+Reduction+and+Percutaneous+Pinning+Type+II+Supracondylar+Humerus+Fracture/0_t9zfmbkn>

* Minimally invasive technique
* Use of pins

# 79.22 - Open reduction of fracture without internal fixation (314)

https://lnav.iso.com/medicallibrary\_icd10/Medical\_Library/Upper\_and\_Lower\_Extremity\_Medical\_and\_Diagnostic\_Procedures/Bones/Open\_Reduction\_without\_Internal\_Fixation.htm

# Classifications

**Sensitivity = True Positive / (True Positive + False Negative)**

* Sensitivity refers to the true positive rate and summarizes how well the positive class was predicted

**Specificity = True Negative/ (False Positive + True Negative)**

* Specificity is the complement to sensitivity, and summarizes how well the negative class was predicted.

**Geometric mean = sqrt(Sensitivity \* Specificity)**

* Combined into a single score that balances both concerns

**Precision = True Positive / (True Positive + False Positive)**

* Precision summarizes the fraction of examples assigned the positive class that belong to the positive class

**Recall = True Positive / (True Positive + False Negative)**

* Recall summarizes how well the positive class was predicted and is the same calculation as sensitivity.

**F-Measures = (2\*Precision \* Recall)/(Precision + Recall)**

* Precision and recall can be combined into a single score that seeks to balance both concerns
* F-Measure is popular metric for imbalanced classification