Designing and Fabricating a Joint Reduction Trainer for Education and Practice of Closed Reductions

How do doctors interact with patients who choose a “risky” course of treatment, and what do doctors try to do in order to avoid patient induced risk?

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How can better performed closed joint reduction improve their use as an option for patient care?

Dislocations are a common form of orthopedic injury that occur when a sufficient amount of force is applied to a limb about a joint that it causes the joint to become disconnected. The overall incidence rate for shoulder dislocations alone was 29.9 per 100,000 in the United States alone (Zacchilli & Owens, 2010). The standard treatment for a dislocation is called a reduction, which fall into two categories: closed reductions and open reductions. Closed reductions are when a doctor moves and applies force to the dislocated joint in order to get the joint back in its socket. This is generally considered to be a safe procedure, but it can carry the risk of fracturing the bones that comprise the joint, as well as making the joint more likely to dislocate in the future. Additionally, a closed reduction is not a procedure that a doctor can practice without a patient who actually has a dislocation, making it more likely for them to do additional damage if they are inexperienced with the procedure. Open reductions are when a surgeon will perform surgery on the joint to put it back into place, and is generally recommended for when there is damage beyond just the dislocation. When approached with these two options, there are many aspects of the problem that the patient must consider before choosing a treatment, such as the level of risk that is inherent to a surgical procedure compared to risks posed by someone pulling on an injured limb with a great deal of force. How a doctor approaches the patient and explains the risks will have a large impact on what the patient is likely to choose as a course of action.

Technical Problem

Designing and Fabricating a Joint Reduction Trainer for Education and Practice of Closed Reductions

What features and design aspects would be most important in a device that is used to train healthcare professionals in joint reductions?

One of the main issues with a closed reduction approach to is the level of experience of the individual performing them. In most cases, the experience a doctor gets doing closed reductions comes while they are doing their residency, they are called upon to assist with a reduction and after enough times assisting with the procedure, they do one. Obviously, it is not something they are expected to do alone or unsupervised, but there can be a great deal of hesitancy when using brute force to move the joint back into place. This hesitancy and uncertainty brings with it the risk of doing further damage to tissues around the joint because of additional shear forces on the joint. Most joints require a fair amount of force being applied when pulling on the limb, which can tear soft tissue. The soft tissues most at risk for damage are muscles and blood vessels (*Joint Dislocation - Symptoms and Causes*, n.d.). Furthermore, it is not uncommon for athletic trainers to perform joint reduction on the spot when an athlete is injured. These reductions are usually performed prior to any imaging being done. Similar to the risk with soft tissue, if there is any damage done to the bone, additional handleing would be quite painful. Any additional damage done during the reduction will add to the time required for the patient to recover, and depending on the severity of the damage, may reduce the functionality of the tissue after it has healed, depending on the amount of scar tissue (Atala et al., 2010).

In order to increase the confidence of care providers and reduce risk of improper reductions, the technical problem I will be addressing is the design and manufacture of a reduction trainer that will require the individual using it to apply the correct forces and techniques in order to reduce the joint in an effective manner. The trainer will be designed primarily with the biomechanics of the joint in mind. This will help doctors and athletic trainers

get comfortable with the amount of force they need to put on a joint when working with reductions before they need to perform one on a live patient. This means that the most important part of the trainer will be to ensure that it accurately reflects the forces and motions necessary to move which ever joint we have designed for. In order to replicate these, we will examine the most common ways the injuries are sustained, and work backwards to generate those forces to give us an approximation of the forces. For example, for a posterior elbow dislocation, we would simulate a fall that a person breaks by outstretching their arm (Layson & Best, 2022). The trainer will also have to be durable enough to withstand the wear and tear of thousands of repetitions so that will have the benefit of letting the users practice as many times as they feel they need to until they are confident in their technique, because the trainer can just be reset and is ready for use. There are currently several additional features that are being considered for incorporation into the design in order to make it more realistic. Some of these additional features include the presentation of anatomical land marks to practice visual identification of other injuries associated with dislocations, and the ability to mimic multiple types of dislocations of the same joint. A trainer that can be used to ensure that a doctor performs a joint reduction without causing damage would be a huge benefit for patients, as it would help them avoid the other pitfalls of taking a surgical approach, such as higher cost, taking time for recovery, and a more involved physical therapy. It is the goal of this project to increase the overall confidence level with which care providers can administer a closed reduction to the joints we provide trainers for; however, being able to track the overall effect that use of a trainer would have is beyond the scope of this project due to the amount of resources that would be required to distribute the trainer on a wide scale, the number of subjects we would need to compare

effectiveness of people who practiced with the trainer against those who did not, and the amount of time needed to generate a useable sample size of reductions performed by those groups.

STS Research Project

Examining Barriers to Explanation of Risk Faced by Doctors

How do doctors interact with patients who choose a "risky" course of treatment, and what do doctors try to do in order to avoid patient induced risk?

One of the key skills that healthcare providers have to develop is the ability to communicate the degree of risk associated with any given treatment to patients. Having this information is crucial for patients to have so that they can make educated decisions about their treatment. In a Commonwealth Foundation survey, minority groups had disproportionately higher rates of incidents that qualified as poor communication between themselves as patients and their physicians. For this survey, poor communication counted any instance of a patient not understanding something their doctor told them, having a question they could not communicate to the doctor, or having a doctor not address their concerns (Collins, 2002). Additionally, patients who encounter a language barrier have an even higher degree of difficulty in communicating effectively with their doctor. These groups have also suffered from historical abuse from medical professionals and systems, and are therefore more likely to have mistrust for doctors, further worsening communication (Armstrong et al., 2007). All of these factors can compound with each other when a physician is trying to communicate risk to impact the understanding and decision making of the patient.

Health literacy is an individual's ability to seek and understand information related to their health. However, this definition is agreed to be extremely broad, and the metrics for

determining health literacy are not agreed upon and difficult to measure (Jordan et al., 2010). This is due to the fact that the measurements have to be either self-reported or made based on the subjective opinion of an observer. Patients with low health literacy have also been identified as receiving worse quality care, and can sometimes end up not even having their initial condition addressed (Williams et al., 2002). Poor health literacy can compound with a doctor's inability to communicate to cause even worse patient-physician communication, as evidence also shows that a majority of patients do not understand what a doctor would consider to be the most basic technical terminology. This can also introduce the problem of a doctor not being able to explain a condition to a patient without medical jargon in a way that still expresses the severity of their condition.

When taken into consideration for choosing treatment, this means that patients might not understand exactly what they are risking when consenting to a procedure. In the context of the problem I am addressing with my Technical Project, a patient might not understand what it means to have a 27% percent recurrence rate for dislocating the joint, which is the rate for patients over 30 who experience a dislocation and have it corrected by a closed reduction (Theivendran et al., 2019). This could easily be interpreted as "there is a 27% chance that the joint just pops out on its own", which is admittedly a terrifying proposition. However, a more accurate explanation would be that some people were participating in the same risky behavior that caused the first dislocation, and the same injury happened in 27% of these cases. This is where it is important for patients to understand, and more importantly for doctors to communicate clearly, that while dislocations are more likely to happen after the first one, risk avoidance is key to prevent future injury. If the patient had sustained the injury because of something like a fall, and they know that avoiding those situations will help decrease the likely

hood of having another dislocation. Continuing with the example of a dislocation, there can be as high as an 8% risk of nerve damage as a result of an open reduction (Polyzois et al., 2016). The possibility of nerve damage would be a powerful deterrent for seeking surgery in this case, even when it might be far more beneficial to the patient overall, both in terms of total recovery and potential additional costs associated with recurrent dislocations.

Additionally, there are several groups that have an understanding of health and medicine that is fundamentally opposed to what doctors can do for them. One example of these types of groups is hardline religious groups that use faith healing as the only acceptable form of medicine, and thus reject any treatment form doctors (Swan, 2020). Obviously, any doctor would consider these courses of action to be risky to the extreme, but they cannot force treatments upon an individual. There are also many cultures that view seeking healthcare as a form of weakness, especially when it comes to mental health.

My research project would be an investigation of how doctors attempt to communicate with patients who they believe are taking undo risks. This would require me to first understand what doctors are legally allowed to do with regards to influencing a patient's treatment decision, which would require research into legal and ethical literature for doctors. I would then reach out to doctors and ask them about instances where they felt that a patient was not choosing the best option for treatment. I would likely try to focus on orthopedic specialists, and attempt to focus further on dislocated joint and broken bones, since I know that there are multiple approaches for treating those. I will then perform interviews with willing doctors to try and gather specific information about how they try to influence patient behavior, and whether or not the doctors feel like that behavior stems from a misunderstanding of risks from certain procedures, and if so, any likely causes of those misunderstandings.

In terms of actor network theory, the main actors are going to be the patients and the doctors interacting with each other. Additional actors could be whoever is acting as an interpreter for patient if they either do not speak the same language as the doctor, or if the accompanying party is more health literate than the patient. The barriers of language and education are the primary sources of friction in the network that keep it from operating smoothly. Conflicting understandings and values related to healthcare between the patient and doctors also affect the dynamic. Introducing my technical solution could help smooth communication in several ways. First it would provide doctors a way to practically demonstrate what it is that they will be doing to the patient. It will also allow patients to ask more comprehensive questions by acting as a physical aid in communicating with a doctor.

Conclusion

Making sure that a patient has all the information they need to make an informed decision is a crucial part of medical ethics. Understanding how minorities have risk explained to them differently and its effect on their care is important in ensuring equity in care. With regards to dislocated joints, there are several key differences in the long-term effectiveness of each approach, and patients may not have the understanding required to fully know the implications of their choice on their long-term health, or they may not have the resources to sustain themselves during the recovery of a potentially more effective treatment. Regardless of the patient's choice, it is the duty of doctors and other healthcare providers to know how to perform the procedures that their patients choose to the best of their abilities. It is the goal of the technical project to create a device that will help train healthcare professionals so that when they have to perform a

closed reduction, they can do it in the easiest, most efficient method possible while reducing risks.

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