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Techniques and Procedures

SHOULDER DISLOCATIONS IN THE EMERGENCY DEPARTMENT: A COMPREHENSIVE REVIEW OF REDUCTION TECHNIQUES

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☐ **Abstract—Background: Shoulder dislocations are a common presentation to the emergency department and one of the most frequent types of joint dislocations. Studies have found that delays from presentation to first reduction attempt and failed attempt at initial reduction are associated with lower rates of overall reduction success. Discussion: This article reviews 26 total reduction techniques, as well as a variety of modifications to these techniques. Each technique has distinct advantages and limitations associated with its use. While there are limited data comparing specific techniques, the individual success rates of most maneuvers range from 60–100%. Conclusion: It is essential for emergency physicians to be familiar with multiple different reduction techniques in case the initial reduction attempt is unsuccessful or patient-specific characteristics limit the ability to perform certain techniques. This article reviews several reduction maneuvers for shoulder dislocations, variations on these techniques, and advantages and disadvantages for each approach. It is intended to serve as a resource for those interested in expanding their knowledge of shoulder reduction techniques.**

☐ **Keywords—dislocation; glenohumeral; reduction; relocation; shoulder**

INTRODUCTION

The glenohumeral joint is a ball-and-socket joint where the humeral head articulates with the glenoid fossa of the scapula. The glenoid fossa is relatively shallow, allowing a wide range of motion at this joint. However, this also increases the risk of dislocations, with shoulder dislocations being one of the most common of all joint dislocations (1–3). Overall, shoulder dislocations have an incidence ranging from 21.9–51.2 per 100,000 population (3–7). Among those with an initial dislocation, approximately 20% will have ≥1 recurrent dislocation (8).

Studies have found that delays from the time of injury and emergency department arrival to reduction attempt are associated with higher rates of failed reduction (9,10). In addition, repeated attempts at reduction may increase muscle spasm and further lessen the likelihood of a successful reduction (9). Repeated attempts at reduction may also increase neurovascular injuries (9). Therefore, it is essential for emergency physicians to be familiar with multiple techniques for reducing a dislocated shoulder, especially if the first technique is unsuccessful. This manuscript summarizes all of the major reduction techniques with accompanying images, success rates, pearls, and pitfalls.

METHODS

PubMed and Google Scholar were searched for articles using a combination of the keywords "shoulder," "glenohumeral," "dislocation," "relocation," and "reduction," as well as individual targeted searches of each of the

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Figure 1. Axial traction with acromial fixation.

identified reduction techniques. The search was conducted from database inception to October 2, 2019. There were no language restrictions. Studies were selected for inclusion based upon perceived relevance as determined by the author, with an emphasis on identifying all major reduction techniques and variations. When available, systematic reviews and meta-analyses were preferentially selected. These were followed sequentially by randomized controlled trials, prospective studies, retrospective studies, case reports, and other narrative reviews when alternate data were not available. A total of 154 articles were selected for inclusion in this narrative review.

DISCUSSION

Anterior Dislocation Reduction Techniques

Axial traction with acromial fixation. This technique was first described by Santos Caudevilla Polo in 2011 (11). This procedure can be performed with the patient in any position, though seated and supine are the most common. With one hand, the clinician holds the patient's forearm or elbow of their affected arm, while the clinician's other hand stabilizes the acromion process (Figure 1). The clinician then applies axial traction to the patient's arm, guided by pain and muscular tension. In 2015, a variation on this (referred to as Aufmesser's method) was described wherein the patient's hand was held instead

Figure 2. Bokor-Billmann technique.

of the elbow and the clinician's trunk was used as a fulcrum to help generate increased force if needed (12). The authors reported a 100% success rate in their retrospective study of 263 patients (12). The technique has been proposed to align the humeral head with the glenoid, such that the muscles will gently pull it into the cavity (12). Advantages of this approach include that it can be performed by a single clinician, does not require a lot of strength, and can be performed with the patient in almost any position.

Bokor-Billmann technique. This approach was first described by Therezia Bokor-Billmann in 2015 (13). It includes 5 steps. First, the patient sits upright against a firm surface to minimize movements of the upper body. Next, the clinician holds the patient's wrist with one hand and the elbow with the other hand. The elbow is flexed to 90° and the humerus is moved to 90° of forward flexion. While remaining in flexion, the elbow is adducted until it reaches the midline of the body. Finally, the elbow is internally rotated while avoiding any other changes in position (Figure 2). Mild resistance is typically appreciated at 25–30° of rotation. When this occurs, apply gentle, steady pressure to overcome this resistance. The reduction will typically occur at 30° of internal rotation. The authors reported a 100% success rate without any complications among their study of 39 patients (13). The authors state that the technique is successful because

Figure 3. Chair method.

it moves the head of the humerus to where the greater tuberosity is smallest and, therefore, has the greatest chance of sliding over the glenoid rim (13). Advantages of this approach are that it can be performed by a single clinician and does not require the patient to be lying in a bed.

Chair method. This method was first described by David White in 1976, though it was popularized by Hilali Noordeen in 1992 (14,15). Since then, there have been numerous publications on this technique (16–23). Begin by having the patient sit in the chair and rotate their body, such that the backrest of the chair is pressed deep into the axilla of the patient's affected extremity with their arm hanging over the backrest. The backrest should be well-padded to avoid injuring the axillary structures. This has been described with the backrest of the chair against the patient's anterior chest, as well as with the patient seated sideways and the backrest in the axilla on their affected side. The clinician then provides gentle downward traction on the hand of the patient's affected extremity (Figure 3). If the reduction is not initially successful, the humeral head may be trapped below the inferior margin of the glenoid. In these cases, a small amount of external rotation may facilitate the reduction. One

Figure 4. Cunningham technique.

study found that external rotation was required in approximately 20% of cases (22). Studies have demonstrated a 96.6–100% success rate without reported complications (19–23).

A few modifications have been suggested since the original technique was described. Noordeen proposed a modification wherein the downward traction is enhanced by having the patient attempt to stand up from the chair while the clinician holds their hand (15). They had a 72% success rate with this modification and noted no complications as a result of the reduction (15). Kuah recommended a "slump" method, wherein the patient slumps forward in a chair with their torso supported by one clinician. A second clinician grasps the affected extremity and applies downward traction longitudinally on the elbow of the affected extremity (24). This technique offers the benefit of reducing the risk of compression in the axilla from the chair's backrest. When studied, this technique was 93.4% successful (24).

In 1995, a group of physicians from the Snowbird Clinic in Utah described a technique referred to as the Snowbird technique (25). Similar to the original chair technique, the patient sits in a chair with the affected extremity placed over the edge and the backrest placed in the patient's axilla. However, with the Snowbird technique, the patient's elbow is flexed to 90° and a 3-foot loop of 4-in stockinette is placed over the forearm. One clinician clasps their hands around the patient's chest

Figure 5. Davos method/Aronen technique.

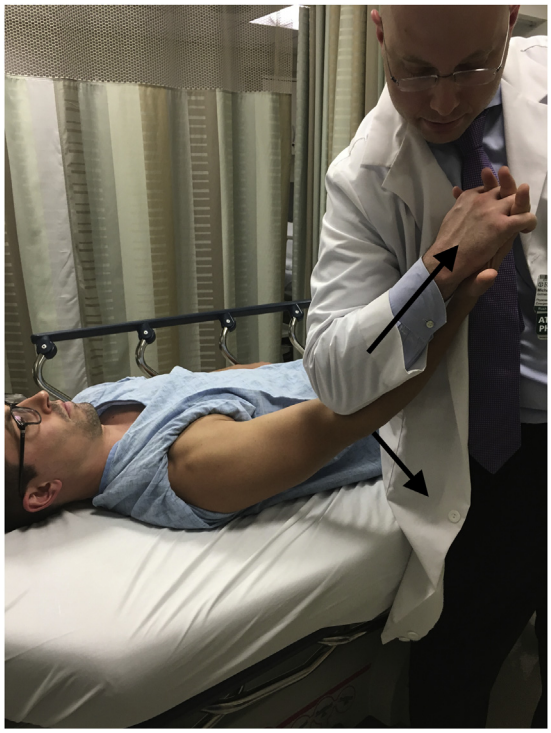

Figure 6. Elbow technique.

providing countertraction, while the second clinician uses their foot to provide downward traction at the elbow by placing it into the looped stockinette. While applying downward pressure with their foot, the second clinician uses their hands to maintain the elbow in flexion and apply gentle rotation as needed. The authors endorsed a 97% success rate without any reported complications (25).

Finally, Philip Hombrey created a specialized chair, referred to as the Oxford chair, to improve upon the original technique by Nordeen (26). This specially designed chair is angled backward to incorporate forward flexion into the downward traction component. Studies have found a 62.3–76.7% success rate with this specialized chair (27,28). No complications have been reported in these studies (27,28).

Both the original technique and modifications are based on fatiguing the muscles to allow gradual reduction of the humeral head. Advantages include that it is relatively fast, can be performed with a single clinician, and does not require the patient to be in a bed. Disadvantages include that the patient must be conscious and alert, difficulty performing this in patients with multiple injuries, and the potential risk of axillary injury, though existing data have not supported this risk (15,21,22,25). In addition, the Oxford chair technique requires a specialized chair that may not be available at most EDs.

Cunningham technique. This was first described by Neil Cunningham in 2003 (29). To begin, the patient must sit upright in a hard-back chair or bed. It is important that the patient sits as upright as possible and without any slouching. The clinician kneels or sits next to the patient. The clinician then places their wrist on the forearm of the patient's affected arm and places the patient's hand on the clinician's shoulder. The clinician should not apply any downward traction at this time, as it can result in muscle spasm. Rather, the weight of the clinician's arm on the forearm will provide sufficient traction. While supporting the affected arm, the clinician slowly and gently moves the humerus into adduction. Once the humerus is in adduction, the clinician sequentially massages the patient's trapezius, deltoids, and biceps muscles (Figure 4). A strong kneading of the biceps between the thumb and fingers is recommended to obtain sufficient relaxation. When the clinician feels that the patient's arm is relaxed, the patient is asked to shrug their shoulders in a superior and posterior direction while the clinician continues to massage the patient's biceps muscle. Once the arm is fully relaxed, the humeral head should relocate quickly and painlessly. Two small case series have demonstrated 100% success rates with this technique (29,30). Sool's technique is a modification of the Cunningham technique but places the arm at 90° of extension and performs gentle traction on the elbow (31). Massaging is focused on anterior deltoid and pectoralis

Figure 7. Eskimo technique.

Figure 8. External rotation maneuver.

muscles (31). The authors had a 75% success rate with Sool's technique (31). It has been proposed that spasm of the biceps brachii muscle can lead to difficulty with reducing a shoulder dislocation. This technique focuses on relaxing the biceps muscle while using the rhomboid muscles to retrovert the scapula, allowing the patient to self-reduce their shoulder (18,29,32). Advantages include that it is quick, painless, and avoids the need for intra-articular injections or procedural sedation. Disadvantages include that the patient must be able to sit upright and that the pain must be reasonably controlled at rest.

Davos method/Aronen technique. This was first reported by John Aronen in 1986 as a potential self-reduction technique for shoulder dislocations (33,34). The original technique involved interlocking fingers to hold the hands together (33). Boss, Holzach, and Matter from Davos Hospital described the more common version in 1993, wherein the patient's wrists are wrapped together instead of the interlocking fingers recommended by Aronen (35–37). As such, this technique is known as both the Davos method and the Aronen technique. For this technique, the patient begins in a seated position on a bed with their ipsilateral knee flexed as much as possible and their hands held in front of their flexed knee. The clinician then uses tape or a folded sheet to hold both hands together (Figure 5). Of note, patients should not use interlocking fingers to hold their hands together because this can increase the associated muscle tone which will make the reduction more difficult. The clinician sits on the bed, preventing the patient's foot from moving forward and using their hands to stabilize the patient's hands against the anterior tibia. The patient is advised to lean their head back and shrug their shoulders as they slowly attempt to lie back in the bed. The patient should keep their elbows close to their knees as they extend their body backward. Studies have demonstrated a 60–86% success rate without any associated complications (36,38–40). It is proposed to allow for a controlled, self-reduction, thereby lowering muscle spasm, while the shoulder shrugs rotate the scapula allowing for better alignment of the glenoid. Advantages include that it can be performed with a single clinician, requires minimal force, and may be less painful because the patient is controlling all steps of the reduction. In addition, clinicians can teach patients to perform this at home for self-reduction among those with recurrent dislocations. Disadvantages include the need for a cooperative and conscious patient.

Elbow technique. This is a newer method which was first described by Honlok Lo in 2019 (41). This reduction is performed with the patient in the supine position. The

clinician grasps the wrist of the affected side with their outside arm and provides gentle, longitudinal traction on the arm. The clinician lifts the arm to 45° of forward flexion and 45° of abduction. The clinician then places their inner arm on the patient's forearm and their corresponding elbow on the patient's mid-humerus. While applying longitudinal pressure in a lateral direction, the clinician uses their elbow to apply force to the mid-humerus in a posterior and superior direction (Figure 6). A second clinician may be needed to stabilize the scapula. The authors reported a 100% success rate among 26 patients without associated complications (41). Advantages include that it can be performed by a single clinician and is relatively quick with a mean reduction time of 5 sec in the original study (41). However, this may be difficult to perform in patients who have large arms. More studies are needed to determine the success of this in different patient populations.

Eskimo technique. While commonly referred to as the Eskimo technique, this was actually originally described by Lewis Stimson in 1901 as the "pendel method" (derived from the Latin word pendulus, or hanging) (42). However, this technique did not gain significant attention until this was redescribed by Sven Poulsen in 1988 as a method of reducing shoulders among Eskimo patients in Greenland (43). The technique is performed with the patient on the ground with their affected shoulder toward the ceiling. Two clinicians lift the patient by the dislocated arm, keeping the contralateral shoulder a couple of centimeters above the ground (Figure 7). If reduction does not occur, the clinician can apply gentle pressure on the humeral head to facilitate the reduction. In the original study, Poulsen reported a 77.3% success rate among a sample of 22 patients (43). Eneas Fusco described a modification of this technique (44). The patient begins in the supine position. The arm is placed in 90° of abduction at the shoulder with 90° of flexion at the elbow. The clinician grasps the affected arm while maintaining 90° of flexion at the elbow. The clinician then asks the patient to roll onto their side and lifts the patient up, applying longitudinal traction on the humerus. They reported a 92% success rate among the 25 patients in their study (44). The Eskimo technique offers the advantage of not requiring any special equipment or beds as it is performed on the ground with the patient's body as a counterforce. Consequently, this may be helpful in austere settings. However, this technique generally requires 2 clinicians and can be difficult to perform if there is limited floor space.

External rotation maneuver. The external rotation maneuver (ERM) was first described by Reinald Leidelmeyer et al. in 1977 (45). Two years later, it was studied among 85 patients at Hennepin County Medical Center (46). It was officially coined the "Hennepin technique" in 1984 (47). However, in 2004, Krishna Kiran Eachempati added 20° of forward flexion before externally rotating the arm (48). This modification was designed to better align the forces of the pectoralis major and subscapularis muscles and is now routinely integrated into the technique. Because of this, the technique has been simultaneously referred to as the external rotation technique of Leidelmeyer, the Hennepin technique, and the flexion-adduction-external rotation technique of Eachempati (16,17,45,46,48–58). The patient begins in the supine position with the clinician standing at the side of the bed and the patient's arm in adduction. The clinician grasps the patient's wrist in one hand and stabilizes the patient's elbow with their other hand. The elbow is flexed at 90°, the shoulder is placed in 20° of forward flexion, and the arm is adducted against the side of the chest. The clinician then slowly externally rotates the patient's arm using the wrist as a guide (Figure 8). No traction is performed during this approach and minimal force should be applied to avoid complications. The shoulder will typically be reduced between 70–110° of external rotation. After reduction, the arm should be rotated internally back across the chest. Numerous studies have been performed on this technique, with success rates ranging from 78% to 100% (46,48–56). Among the studies assessing complications, none have been reported for this technique (48,50–53). While downward traction is generally not recommended because of the potential risk to injure the humeral head, 1 study found that it had an 86.4% success rate with no significant complications (59).

A few variations have been described for the ERM. Boehler described having the patient sit in a swivel-top chair and hold the leg of a piece of heavy furniture (60). The patient then slowly rotates their body 70–110° to self-reduce their shoulder (60). In 2019, Akcimen described the modified ERM (56). For this technique, a 5–10 cm stiff and inflexible object (e.g., a 1-L water bottle) is placed in the patient's axilla. During the reduction attempt, pressure is applied to the elbow in the direction of the patient's body, using the object as a fulcrum for the reduction. In their study, both ERM and modified ERM had 100% success rates, but the modified ERM was twice as fast (1.34 min vs 3.05 min) (56). Finally, Prakash's maneuver is another variation on this technique which reordered the reduction steps (61,62). The patient begins in the seated or standing position. The elbow is flexed to 90° and externally rotated until it is parallel to the body. Then, the arm is adducted and forward flexed such that the elbow is in front of the body (approximately 20° of forward flexion). Finally, the arm is internally rotated so that the fingers touch the opposite shoulder. Similar to external rotation, no traction is applied during the

Figure 9. FARES method.

reduction. Two studies have both demonstrated 100% success rates with this technique (61,62). No complications were identified in either study (61,62). Overall, ERM offers the advantage of being relatively atraumatic and has less pain because no traction is involved, as well as requiring only a single clinician. However, it is less likely to be successful if performed without adequate analgesia or if muscle spasm is present.

FARES method. The FARES (FAst, REliable, and Safe) method is an acronym, but was also named after Fares Sayegh, the person who first described it (63). The patient begins in the supine position with the clinician standing along the side of the bed and the patient's arm in adduction. The clinician grasps the patient's affected wrist with both hands, keeping the patient's elbow extended and forearm in a neutral position. The clinician slowly abducts the arm while keeping gentle and steady longitudinal traction on the dislocated arm. It is important that traction remains relatively mild and countertraction should not be necessary. While performing the abduction, the clinician performs brief (2–3 per second) vertical oscillations (approximately 5 cm above and below the horizontal level) (Figure 9). Once the arm approaches 90° of abduction, the arm should be rotated externally, while continuing the in-line traction, abduction, and vertical oscillations. The shoulder will typically be reduced at 120° of abduction. After the shoulder reduces, the upper limb should be internally rotated with the elbow flexed and forearm crossing the chest. Several studies have assessed the FARES method, with success rates ranging from 85.7% to 100% and no reported complications (51,63–65). One study directly compared the FARES technique with ERM and found that FARES had a shorter time to reduction, was less painful, and required fewer attempts at reduction (51). The authors proposed that the gentle oscillations facilitate the reduction by releasing the humeral head from any entrapment and relaxing the muscles (63). Advantages with this technique include that it can be performed with a single clinician, requires minimal traction, and is faster than other techniques (51,63). It has also been successfully used for posterior dislocations (66). There are no major limitations to this technique.

GONAIS method. The GONAIS technique was first described by Shiro Gonai in 2016 and is also an acronym

Figure 10. GONAIS method.

Figure 11. Hippocratic method.

standing for: Grasp a waist-high object, Opposite arm assists, Non-sedated, Autoreduction/autotraction, Immobilize the grasped object, and Squatting and stooping (67). First, the patient or clinician immobilizes an object for the patient to grasp which is at the level of the patient's waist (e.g., bedrail). The patient grasps the immobilized object. The patient may bend backward, stand on their toes, or bend the ipsilateral elbow when grasping the object. The patient applies gentle traction on their affected arm. The patient then gradually steps backward and leans over to forward flex and abduct the dislocated shoulder (Figure 10, A). When the angle of the trunk and affected arm is approximately 90°, the patient begins to squat. Continuous traction should be maintained, and the angle should remain at 90° throughout the entire time that the patient is squatting. After squatting completely, the patient stoops forward and moves a few steps backward (Figure 10, B). If reduction does not occur at this point, the patient should apply pressure to the humeral head in a superior direction with the opposite hand to reduce the dislocation. This technique offers the advantages that the patient can learn to self-reduce their shoulder. However, it also requires that the patient has the mobility to squat down and that stabilized objects of the proper height are available. In addition, because this was only described as a case report, further prospective studies are needed to better determine the actual success rate.

Hippocratic method. This is one of the oldest reduction techniques, first described by Hippocrates in 400 BC, but has fallen out of favor in current medical practice (68). The patient is placed in the supine position. A towel or sheet is placed into the patient's axilla on the affected side. A clinician grasps the wrist of the affected arm with both hands. The clinician places their heel into the padded axilla of the patient. Longitudinal traction is applied to the affected arm using the clinician's foot as countertraction (Figure 11). The arm is abducted to approximately 30° while maintaining in-line traction. Gentle rotation, abduction, adduction, flexion, and extension may be performed to facilitate the reduction. This technique has been reported to have a 72.5–100% success rate (63,69). Two variations have also been described for this. With Bennett's technique, the clinician uses their contralateral hand for countertraction instead of their foot (60). Aronen also described a modification of this technique where the foot is placed against the lateral chest wall instead of the axilla (34). While this technique does offer the advantage of only requiring a single clinician, there is a significantly increased risk of fractures of the humerus and neurovascular injury (70,71). Consequently, this technique is no longer recommended.

Figure 12. Janecki's forward elevation maneuver.

Janecki's forward elevation maneuver. This was first described by Chet Janecki in 1982 (72). The patient begins in the supine position with the clinician standing on the side of the patient. The clinician grasps the wrist of the affected arm and slowly elevates the arm in forward flexion until the arm is at approximately 90° of flexion. The arm is then slowly abducted until reduction occurs (Figure 12). Gentle traction is applied during this part of the process. If reduction does not occur, the arm is internally rotated while the clinician applies gentle pressure to the humeral head with their thumb or fingers. Studies of this maneuver have reported a 92.6–100% success rate without associated complications (72–74).

Figure 13. Kocher technique.

Advantages include that it can be performed with a single clinician and has a low risk of complications.

Kocher technique. This is the oldest described technique, with 1 Egyptian wall painting of this technique dating back to 1200 BC (75). However, this technique was first published in the medical literature by Theodore Kocher in 1870 (76). Traditionally, this is performed with the patient supine on the bed. The clinician places 1 hand on the elbow of the affected arm and the other hand on the patient's wrist (Figure 13). The patient's elbow is flexed to 90°. The patient's arm is adducted against the body. The clinician then uses 1 arm to externally rotate the forearm until there is resistance (approximately 60–70°). The arm is then further adducted until reduction occurs. If no reduction occurs, the patient's arm is then elevated in forward flexion. Finally, the patient's forearm is internally rotated with the affected hand placed on the patient's contralateral shoulder. This technique has been extensively studied in the literature with success rates ranging from 68% to 100% (63,76–83). Several studies have identified no complications in relatively large samples when following Kocher's original description of the technique (63,82,83). Of note, the original description of the Kocher technique recommended no traction be applied (76). However, many modern descriptions have included axial traction on the humerus as a component (23,82,84–86). This modified Kocher technique has been found to have a success rate of 72–97.5% (23,82,84–86). While most studies had no significant complications, 1 patient was found to develop a humeral neck fracture as a direct result of the traction-based Kocher technique (84). Due to the increased risk of complications, the application of traction is generally not recommended (87,88). The advantages of the Kocher technique are that it can be performed by a single clinician and is less painful and relatively safe as long as it is performed without traction.

Legg reduction maneuver. This maneuver was named after William Legg, who developed this in the 1980s (89). The patient should begin seated in a straight-backed chair. An assistant stabilizes the unaffected shoulder by applying slight downward pressure. The patient is instructed to abduct their affected arm to 90°. If this is not possible, the clinician can assist with this. The clinician externally rotates the affected arm, so that the palm is facing upward (Figure 14, A). The clinician flexes the elbow to 90° (Figure 14, B). During this step, it is important that the arm remains in the coronal plane, such that the elbow and forearm remain posterior to the patient's occiput. The affected arm is then adducted towards the patient's side while fully flexing the patient's elbow (Figure 14, C). The patient is asked to actively internally rotate their affected arm across their chest (Figure 14, D). The technique is intended to neutralize the muscle groups that resist reduction. By abducting the arm, the deltoid and supraspinatus muscles relax. External rotation relaxes the rotator cuff muscles, while flexion of the elbow relaxes the coracobrachialis and biceps muscles. The actual reduction occurs at the end of the maneuver during internal rotation. Advantages of this technique include the avoidance of traction. Disadvantages include the need for 2 clinicians and the lack of data on success rates.

Milch technique. Although often attributed to Henry Milch, this was actually first described by Sir Astley Cooper in 1832 (90,91). Similar to Kocher, the original technique did not involve any traction, but this was added in most modern iterations (10,16–18,53,57,68,84,92–95). This is typically performed with the patient in a bed either supine or with the head of the bed elevated at 30°. The clinician places 1 hand in the axilla of the patient's dislocated shoulder. The clinician palpates the head of the humerus and places their fingers on the medial surface of the dislocated humerus. The clinician then uses their other hand to grab the wrist of the patient's affected arm and gently abduct the arm to an overhead position (Figure 15). While abducting the arm, the clinician applies firm pressure to the humeral head in a medial and upward direction. Once the arm is fully abducted, it is

Figure 14. Legg reduction maneuver.

externally rotated and gentle, in-line traction is applied. After the shoulder relocates, the arm is gently adducted, lowered, and placed in immobilization. Success rates with this technique ranged from 69.2% to 100% without any reported complications (10,53,84,92–97).

A few modifications have been described for this technique. Lacey and Crawford described a modification wherein this is performed in the prone position (98). The authors purport that this may reduce discomfort by relaxing the arm musculature compared with the supine method. Lacey and Crawford also recommended flexing the elbow to 90° to relax the biceps muscle. The authors had 100% success with this technique (98). McNair further modified the prone approach from Lacey and Crawford by having the patient begin with downward traction (similar to the Stimson technique) before beginning the reduction (99). The authors had a 90% success rate with this "hanging arm" technique (99). Dudkiewicz et al. described a modified self-reduction technique, wherein the patient would abduct and externally rotate their affected shoulder with their contralateral arm (100). They would then apply a posteriorly directed pressure to the anterior humeral head using their unaffected hand while slowly lowering their arm back into position. This modified technique had a 97% success rate (100). Both Canales Cortés et al. and Singh et al. described a modification of this technique, wherein the arm is abducted to 90–120°, followed by 90° of external rotation and 30° of forward flexion (101,102). Using this modified Milch technique, the authors had 83% and 83.9% success rates, respectively, with no reported complications (101,102). The focus for all of these techniques is to align the arm with the "zero position" (103). In a dislocated arm, the muscles are often contracting in different planes. By abducting the arm, the muscles can better align their direction towards the joint and facilitate the reduction (103). Advantages of this technique are that it can be performed with a single clinician (or as a self-reduction technique) and has a low risk of complications (10,53,84,92–97,100). There are no major disadvantages with this technique.

Nicola method. This was first described by Toufick Nicola in a case series of 27 patients in 1949 (104). The patient begins in a chair with the clinician standing behind the

Figure 15. Milch technique.

Figure 16. Nicola method.

patient. The clinician makes a closed fist and places their hand inside the patient's axilla with the thumb facing the affected arm. The patient rests the forearm of their affected arm on their ipsilateral thigh. The clinician applies gentle downward traction at the elbow using their opposite hand. The clinician then gently pulls the elbow medially using the axillary hand as a fulcrum to facilitate the reduction (Figure 16). Success rates have ranged from 88.6% to 100% (104–106). In a study by Manes, 2 patients had transient neuropraxia after this reduction technique, but no other complications have been reported (104–106). In 1980, Manes recommended using the clinician's forearm to directly apply superolaterally directed pressure on the humeral head to facilitate the reduction (105). In 1994, Bhan and Mehara proposed a modification to this method using the patient's body to create countertraction (107). The patient begins in the lateral position with their unaffected side downward. The clinician grips the affected limb by the proximal humerus with both hands and lifts laterally (i.e., perpendicular to the long axis of the humerus). For anterior shoulder dislocations, a force is applied toward a posterior direction and for posterior dislocations, it is applied anteriorly. Bhan and Mehara reported a 100% success rate for this modification (107). Advantages of the Nicola method include that it can be performed with the patient already seated in a position of comfort and can be performed with a single clinician. Disadvantages include the potential risk of injury to the patient's axilla or clinician's fist if improper technique is used.

Scapular manipulation. This technique was originally described by Bosley and Miles in 1979 at the American Association of Orthopedic Surgeons annual meeting (108). To begin, the patient is placed in the prone position with the affected shoulder in 90° of forward flexion. One

Figure 17. Scapular manipulation.

clinician applies downward traction to the affected shoulder. If only 1 clinician is available, this can be performed with a 5- or 10-lb weight instead. The clinician then pushes the inferior tip of the scapula in a medial direction using their thumb, while the superior portion of the scapula is stabilized with the other fingers (Figure 17). Some authors have also suggested applying a small amount of downward pressure to the superior portion of the scapula using the fingers to increase the rotational movement of the scapula (85,109,110). This technique has been extensively studied and has a success rate ranging from 78.4% to 100% without reported complications (55,85,109–115).

There have been several modifications to this approach described in the literature. Ahmed et al. recommended adding 10–15° of external rotation during the inline traction and had a 100% success rate with this modification and no reported complications (116). Several authors have also suggested flexing the patient's elbow to relax the biceps tendon and facilitate the reduction (85,109,116). McNamara described this in the seated position by having a second clinician perform traction in forward flexion with 1 hand pulling the patient's arm forward while the other hand applies a counterforce at the clavicle to stabilize the patient's chest (112). Doyle and Ragar described this in the supine position with 1 clinician elevating the extremity in 90° of forward flexion (117). Another approach, the single-operator scapular

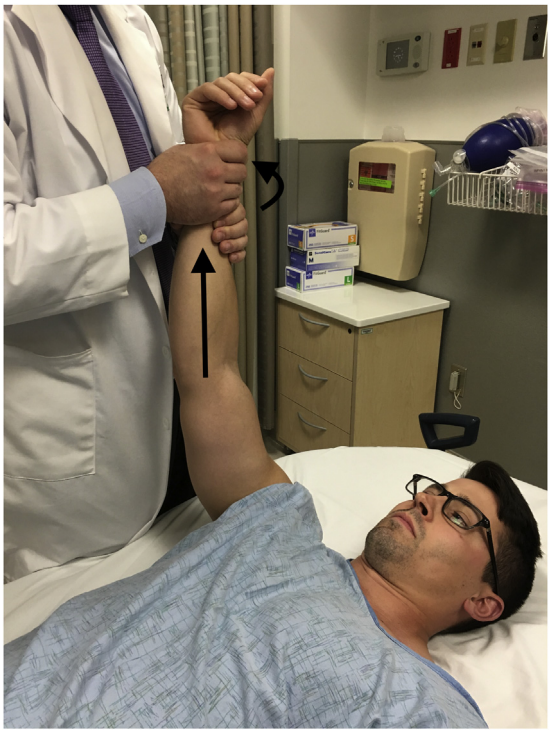

Figure 18. Spaso method.

Figure 19. Stimson technique.

manipulation and traction-countertraction (SOSMAT), has also been described (118). With the SOSMAT technique, the clinician ties one end of the bedsheet around the wrist of the affected extremity while wrapping the other end around the clinician's distal femur. The clinician then steps onto the bedsheet with their foot, applying downward traction on the patient's arm. This has been proposed to allow the clinician to have more control and downward force while performing the scapular manipulation when only 1 clinician is available. Finally, the best of both techniques is a modification of the scapular manipulation method by providing downward traction in place of forward flexion (119). For this approach, the patient sits on a bed with the head of the bed elevated to 90°. They rest their unaffected side against the elevated head of the bed. The first clinician places 1 hand on the affected side's forearm and a second on the patient's wrist. The clinician leans over the patient, providing downward pressure on the forearm, while gently internally and externally rotating the arm via the wrist. A second clinician performs scapular manipulation.

The scapular manipulation technique differs from most other reduction techniques because of the focus on moving the glenoid toward the humeral head instead of moving the humerus toward the glenoid. Advantages of this technique are that it can be performed with a single clinician, requires minimal force, has a low risk of complications, and can be performed in almost any position (ie, prone, seated, or supine). The only major challenge to this technique is that it may be more challenging to palpate the scapular tip in large or muscular patients.

Spaso method. This was first described by Spaso Miljesic and Anne-Maree Kelly in 1998 (120). The patient begins in the supine position. The clinician grasps the wrist or distal forearm of the affected extremity and gently lifts the patient's arm toward the ceiling in forward flexion. While lifting the arm, the clinician also externally rotates the patient's arm (Figure 18). During this technique, it is important to avoid excessive force. When significant pain is present, patients may elevate their affected shoulder off the bed. If this occurs, stop any further movement but maintain traction until the pain subsides. If there is difficulty with reduction, the clinician can also apply gentle pressure on the humerus with the other arm to facilitate the reduction. Success rates range from 66.7% to 100% without reported complications (23,40,83,121–124). Matsumoto et al. described a seated version, wherein the clinician raises the patient's arm to 90° of forward flexion (74). The clinician then places 1 hand on the anterior chest wall while the other hand applies longitudinal traction to the arm. The authors reported a 79.4% success

Figure 20. Traction/countertraction for anterior and posterior dislocations.

rate and no complications with this modified technique (74). Advantages of these techniques include that they are relatively simple to perform, do not apply pressure on the brachial plexus, and can be performed with a single operator. However, it can be more challenging to perform this with heavier patients.

Stimson technique. This was originally described by Lewis Stimson in 1900 (125). The patient is placed prone on the bed. Downward traction is applied by the clinician or by attaching a 5- to 10-lb weight to the patient's affected arm (Figure 19). The shoulder will typically reduce within 10 to 20 min. There are surprisingly few studies of this technique, with 1 study reporting a 28% first attempt success rate (overall success rate not available), while another study had a 91.3% overall success rate (10,126). Some authors have suggested slight external rotation during the downward traction, as well as flexion at the elbow to relax the biceps and facilitate the reduction (60,127,128). Another modification involves having the patient lie prone in a bed while gripping the bottom of the bed with their affected arm. The clinician then slowly raises the height of the bed until the patient's shoulder reduces (129). A modification of this technique has also been described using the controls on electric beds (130). The mechanism is proposed to work by using continued traction to fatigue the musculature, allowing the shoulder to reduce. One major advantage of this technique is that the clinician does not have to remain in the room during the reduction attempt as long as another provider can monitor the patient. Disadvantages include that it has a longer reduction time than other techniques and requires the patient to be in the prone position, which can make it more challenging to monitor the patient's respiratory status.

Traction/countertraction. This was first described by Charles Rockwood and Michael Wirth (131). Before the reduction, a folded cloth is around the patient's chest and they are placed in the supine position. The affected arm is placed in 90° of abduction. One clinician grasps the patient's wrist and applies longitudinal traction to the affected arm, while a second clinician provides countertraction using the folded sheet (Figure 20). The pressure is gradually increased until the shoulder reduces. Gentle internal and external rotation may be applied to facilitate the reduction attempt. The clinician can also apply direct pressure to the humeral head to facilitate the reduction. While folded bedsheets are commonly used, traction straps have also been described (132). Success rates have ranged from 91.5% to 100% (23,102,115,132).

Figure 21. Double-traction method.

A few modifications have been described for this technique. Waldron recommended flexing the patient's affected elbow to 90° and then wrapping a sheet around the clinician with the patient's arm in the center of the sheet (133). The clinician then leans backward, leaving their hands free to perform gentle internal and external rotation at the elbow. This is suggested to relax the biceps brachii muscle which may facilitate the reduction (57). Bakshi, Tajima et al., and Orbach et al. have each independently described a 3-person, double-traction method, wherein 1 person applies longitudinal traction on the humerus at approximately 30–45° of abduction, a second person applies 90° of lateral traction on the proximal humerus, and a third person applies countertraction to the

Figure 22. Zahiri technique.

chest (Figure 21) (134–136). Success rates for the double-traction method range from 90% to 100% without reported complications (134–136). The traction-countertraction technique shares a similar mechanism with the Hippocratic technique but avoids direct pressure in the axilla by using the sheet across the body in place of the clinician's extremity. The method has a higher overall success rate than many other methods but has several disadvantages. It requires multiple clinicians (2 for traction-countertraction, 3 for the double-traction technique), has a greater risk of nerve injuries, and can be quite painful for the patient, often requiring procedural sedation (137).

Zahiri technique. This was first published in 1997 by Hormoz Zahiri (138). For this technique, the patient begins in the supine position. The clinician flexes the elbow of the affected arm to approximately 120°. For a right-sided dislocation, the clinician places their left forearm between the patient's humerus and forearm with the clinician's hand pointed toward the patient's chest. The clinician's right hand grasps the patient's right wrist (Figure 22, A). The clinician grasps their own right forearm with their left hand creating an "arm lock." The patient's shoulder is slowly flexed to 90° while maintaining 120° of flexion at the elbow (Figure 22, B). The clinician provides traction on the shoulder, while performing gentle external rotation for approximately 1 min (Figure 22, C). The shoulder is then internally rotated until reduction occurs (Figure 22, D). The authors reported an 84.6% success rate without any associated complications (138). They propose that their approach is successful because of 3 components: disengaging the anterior capsule of the glenohumeral joint from the humeral neck, shortening the biceps to reduce "bowstringing effect" from the long head of the biceps muscle, and aligning the muscles to decrease the effort needed for reduction. Advantages of this technique is that it can be performed with a single clinician. Disadvantages include that it is more complicated than other reduction techniques and that it can be more challenging in patients who have larger arms.

Specific Techniques for Posterior Dislocations

Most dislocations are anterior (96.4%), with posterior comprising 3% and inferior dislocations representing only 0.6% of all shoulder dislocations (1). While less common, posterior dislocations present unique challenges to reduction attempts because of the different location of the humeral head with respect to the glenoid. In addition, these patients will often have difficulty with external rotation, so many of the traditional anterior reduction techniques will be difficult to perform in these patients (139,140). As such, they are discussed separately here.

Wilson's technique. This was originally described by John Wilson in 1949 (140,141). The patient begins in the seated position with their arm held in adduction and internal rotation across their chest wall by 1 clinician. This

Figure 23. Wilson's technique.

Figure 24. DePalma's "lever" method.

clinician then applies inline traction, while maintaining the arm in adduction. A second clinician applies pressure with both thumbs to the posterior aspect of the humeral head (Figure 23). Wilson and McKeever reported success in 100% of 8 patients in the original description of the technique. Bell subsequently reported success in another case report and a case series by DeWall et al. reported success in 4 patients (142,143). Advantages of this technique include that it is relatively simple to perform and that it can be performed with minimal movement of the patient. Disadvantages include that 2 clinicians are needed. As with most posterior shoulder reduction techniques, there are limited data on success rates because of the relatively low overall frequency of occurrence.

DePalma's "lever" method. This can be performed in the supine or seated position. The affected arm is adducted and placed in internal rotation. One hand grasps the proximal forearm and applies medial and downward traction, while the second hand applies a laterally directed force at the mid-humerus (Figure 24). Mimura et al. reported successful reduction in 2 consecutive cases in their case report (144). Godry et al. describe a modification of this, wherein the clinician begins in 30° of abduction and 90° of internal rotation (145). The clinician then places their forearm between the humerus and chest wall and applies longitudinal traction to the affected arm with their other hand. Then, they use their forearm as a fulcrum to perform hyperadduction (Figure 25). For posterior dislocations, the humeral head is often impacted on the glenoid rim. As a result, the arm needs to be hyperadducted and internally rotated to release the humeral head, which is the emphasis with this technique. The primary advantage is that it can be performed with 1 person. However, the disadvantage is that it can require significant strength. In those cases, 2 clinicians may be necessary to allow adequate traction.

Caudal traction. This was first reported by Anthony Mattick in 2001 (146). He noted that reduction of the posterior shoulder dislocation occurred during a Swimmer's view radiograph, which was achieved by purely downward traction of the affected arm (146). The author proposed that isolated downward traction may be sufficient to reduce the posterior shoulder dislocation (Figure 26). The advantages include the simplicity of the technique and that only a single clinician is needed. While it was successful in this single case report, further studies are needed to evaluate the effectiveness of this technique.

Specific Techniques for Inferior Dislocations

Similar to posterior dislocations, inferior dislocations are uncommon occurrences that require unique considerations based on the inferior displacement of the humeral head. Inferior dislocations (also known as "luxatio

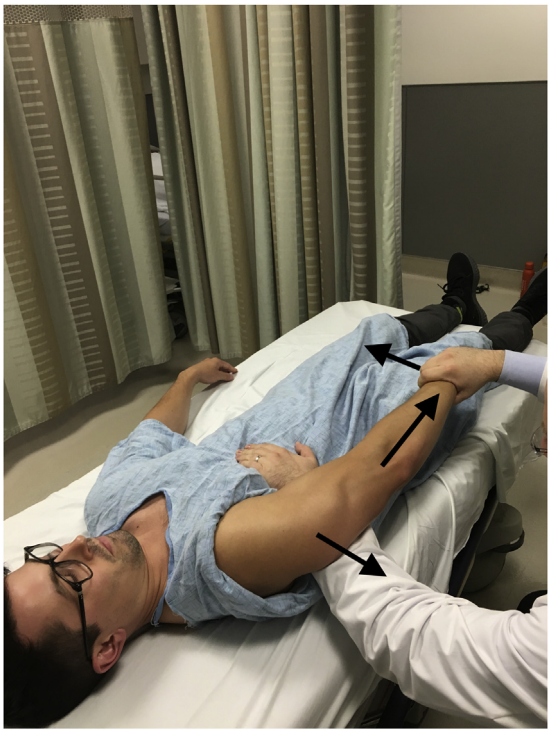

Figure 25. Godry's modified lever method.

erecta") are often more clinically apparent than other dislocations, as the injury causes hyperabduction at the glenhumeral joint, resulting in the patient's arm being locked in position above their head. Inferior dislocations are particularly unique, as traditional anterior and posterior dislocation reduction techniques are not appropriate for this type of dislocation.

Traction/countertraction. It is difficult to determine the exact origin of this technique, as it has been commonly used as the primary reduction technique for inferior dislocations for a long time (147–152). The patient begins in the supine position. One clinician applies longitudinal traction on the humerus, while a second clinician applies countertraction using a bedsheet wrapped around the patient's mid-clavicle. Direct pressure may be applied to the humeral head to assist with the reduction. The arm is then gently abducted until it reduces (Figure 27). The literature consists primarily of case reports demonstrating successful application of this technique (147–152). The exact success rate is unclear given the relative infrequency of inferior dislocations. The advantages include the relative ease of this technique. Disadvantages include the need for multiple

Figure 26. Caudal traction.

Figure 27. Traction/countertraction for inferior dislocations.

Figure 28. Two-step maneuver.

clinicians and the potential for iatrogenic injury from the traction forces.

Two-step maneuver. The 2-step maneuver is a newer technique first described by Shane Nho in 2006 (153). This technique involves first converting the inferior dislocation into an anterior dislocation, and then reducing the anterior dislocation. For this technique, the patient is placed in a supine position. The clinician stands at the head of the bed. The clinician's inner hand is placed on the lateral aspect of the proximal humerus, while the clinician's outer hand is placed on the medial condyle of the elbow. The inner hand leverages the humeral head from an inferior to an anterior position, while the outer hand gently pulls the elbow in a superior direction (Figure 28). Once the humeral head has rotated to the anterior position, the clinician should now be able to adduct the patient's humerus against their body. The anterior dislocation can now be reduced using any of the previously mentioned techniques. The original authors reported 2 successful reductions with this technique and Saseendar et al. reported another successful reduction in their case report (153,154). This offers the advantage of being performed with a single clinician and is relatively easy to perform. The disadvantage is that it converts the inferior dislocation into an anterior dislocation, which will require a second reduction attempt and may result in a longer time to reduction.

SUMMARY

While this article provides a review of numerous techniques for shoulder reduction, there are relatively few comparative trials and the success rates varied significantly between studies. As such, it remains unclear which technique is better. Consequently, the decision regarding which technique to use should be tailored to the individual patient and clinician. For example, a patient who requires close airway monitoring should not be placed prone, while a patient with pulmonary edema may benefit from a reduction performed in the seated position. It is also important to note certain similarities between the various techniques. Clinicians should avoid rapid movements or excessive traction, instead focusing on slow and controlled movements. It is important to wait for muscular relaxation before any rotational movements to improve success rates and avoid complications. In addition, multiple techniques and modifications for anterior dislocations recommended passive flexion at the biceps muscle and external rotation of the arm to facilitate the reduction. Finally, should the first reduction attempt be unsuccessful, the clinician should attempt a different technique on the subsequent attempt. Therefore, it is essential that emergency physicians be familiar with multiple reduction techniques to ensure the highest likelihood of successful reduction.

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