Arterial TOS Comprehensive Overview

SYMPTOMS

Arterial TOS is when the axillary-subclavian artery is compressed within the scalene triangle and the costoclavicular space. This condition typically involves the presence of a blood clot, aneurysm, and/or damage to the vessel wall leading to physiologic abnormalities of the artery. A blood clot is a gel-like collection of blood that forms in your veins or arteries when blood changes from liquid to partially solid. A blood clot in an artery carries with it the risk of traveling or spreading clots to smaller arterial branches further downstream. A blood clot in an artery obstructs the artery preventing blood from flowing through it. When the axillary-subclavian artery becomes obstructed, blood cannot get to the arm. When blood cannot get to the arm, it results in ischemia. With ischemia, part of the arm can begin to die, and if left untreated, the patient can lose the arm. An aneurysm occurs when part of an artery wall weakens, allowing it to abnormally balloon out or widen which can lead to the formation of a clot. If an aneurysm grows large enough, it can burst or rupture leading to dangerous bleeding which, in the case of ATOS although exceedingly rare, can be life and/or limb threatening. Because ATOS involves various stages and forms of arterial obstruction, it can present anywhere from asymptomatic to very severe symptoms.

Symptom Features:

- Average age at presentation is 35-40 but can occur at any age
- Patients are typically young, healthy, and active
- Usually presents on 1 side of the body at a time
- Can range from asymptomatic to mild symptoms to severe symptoms
- Can occur suddenly or gradually over a period of time
- Can occur either at rest or be activity induced particularly with overhead activities
- Almost aways associated with a cervical rib or other bony abnormality

Symptoms:

- Asymptomatic especially in the setting of aneurysm or pre-aneurysmal widening of the artery
- Fatigue, cramping, heaviness, or pain/aching in the arm especially with use or exercise
- Pain in the arm, hand, or fingers
- Numbness and/or tingling in the arm, hand or fingers
- Cold feeling arm, hand, or fingers
- Pale, bluish or mottled appearance of the arm, hand, or fingers
- Delayed capillary refill in the fingers
- Pulse near the elbow and wrist (brachial, radial, or ulnar pulses) may be weak or absent
- A pulsing, non-tender lump or bulge at the base of the neck in the area above and around the collarbone may represent an aneurysm
- Raynaud's syndrome phenomenon in the hand or fingers
- Blood pressure in the affected arm may be lower than the other arm by approx. 30 mmHg
- In severe cases of ischemia and where a clot in the subclavian artery has traveled or spread to smaller arteries lower down in the arm, there can be non-healing wounds or ulcers on the fingertips or small spots on the fingers that appear as dark bruising or blood blisters under the skin

- Very rarely, in the presence of a clot in the artery, a stroke can occur. This happens when the blood flowing through the axillary-subclavian artery reverses and flows in the opposite direction of normal with blood flowing from it to the vertebral artery which can dislodge the clot and allow it to travel to the vertebral artery which provides blood flow to the brain. Symptoms of this stroke can include arm numbness, weakness, or paralysis, speech dysfunction, facial numbness or paralysis, headache, vomiting, difficulty walking, or dizziness.

DIAGNOSIS

DIAGNOSIS CHARACTERISTICS

The diagnosis of ATOS has always been a bit confusing especially for doctors who do not specialize in TOS. It frequently involves a lot of misdiagnoses of ATOS when the correct diagnosis is actually NTOS. This is typically due to the fact that there is some symptom overlap between the two conditions in combination with misinterpretation of the significance of loss of pulse or blood flow with the arm elevated.

KEY POINTS

- ATOS is extremely rare and is almost always associated with a cervical rib or other bony abnormality. The likelihood of ATOS being present is very low when there is no evidence of a cervical rib or bony abnormality.
- Many normal asymptomatic humans will have compression or obliteration of the artery and/or loss of pulse with the arm elevated. Therefore, this finding by itself is **NOT** considered to be ATOS.
- Patients with symptoms consistent with NTOS including those with hand/finger discoloration and temperature changes who lose their pulse with arm elevation are **NOT** considered to have ATOS.
- A critical element of ATOS diagnosis is the presence of damage or injury to the wall of the artery resulting in artery dilatation or widening, aneurysm or a clot.

Who Diagnoses & Treats ATOS?

Any doctor who is familiar with ATOS can give a preliminary diagnosis. These most commonly are emergency room physicians or non-TOS specialist vascular surgeons. However, given the large number of NTOS patients who are misdiagnosed as having ATOS, these can also be orthopedic surgeons or neurologists. Once a diagnosis of ATOS is suspected, referral should be made to a TOS specialist to make a definitive diagnosis and treat accordingly. TOS specialists are usually vascular surgeons and occasionally cardiothoracic surgeons. However, most vascular surgeons and cardiothoracic surgeons DO NOT specialize in TOS. In fact, most of them have very little experience with TOS. Therefore, it needs to be a vascular surgeon or cardiothoracic surgeon who specifically specializes in TOS.

PHYSICAL EXAM

Physical exam is important in a patient with suspected ATOS as it can help distinguish from NTOS, determine the severity of any ischemia, and help determine the best next step in the diagnostic process. Below is a list of what is typically assessed during a targeted ATOS physical exam:

- Temperature of the arm, hand, or fingers

- Color of the arm, hand, or fingers
- wounds or ulcers on the fingertips
- small spots on the fingers that appear as dark bruising or blood blisters under the skin
- Extremely delayed capillary refill (applying pressure to the skin until it turns white & timing how long it takes for the blood to return and the skin to return to normal color)
- sensation of the arm and hand
- Symptoms triggered with arm elevation
- Checking the pulse of the arteries in the arm with comparison to the opposite arm either by finger pressure and/or handheld doppler ultrasound
- Exam of the neck and area just above the collarbone for any masses or abnormalities that might be a cervical rib or aneurysm
- Blood pressure measurements in each arm
- Stethoscope exam of the areas just above and just below the collarbone to identify sounds indicating turbulent blood flow
- Identification of any signs of NTOS or VTOS

TESTING

Vascular Testing

Duplex or Doppler Ultrasound this is the least invasive, least expensive, and most readily available test out there to check for blood clots and blood flow abnormalities. Duplex ultrasound involves using high frequency sound waves to look at the speed of blood flow, and structure of the arteries. It involves an instrument called a transducer being placed on the skin in the area of the artery being imaged, and it is moved around on top of the skin to get different views in different areas. It can also be performed with the arm in different positions. However, by itself, compression of the artery or loss of pulse with the arm elevated is not diagnostic of ATOS. This test can visualize an aneurysm. However, more advanced imaging such as angiogram would need to be done to assess the location and exact condition of the artery. Along with the ultrasound, something called segmental pressure testing can also be done which uses blood pressure cuffs to measure the blood pressure in different locations on the arm. It compares the blood pressures of two locations on the arm and a difference in blood pressure can indicate where a blockage of blood flow might be.

Photoplethysmography (PPG) This is a non-invasive test which involves clips being put on the ends of the fingers. These clips contain infrared light sensors which can detect blood flow changes via the light traveling through the skin surface and being absorbed by blood. It can detect intermittent blood flow changes particularly with the arm in certain provocative maneuver positions. The finger clips are connected to a machine which converts the blood flow changes into waveforms and displays them on a graph in the report. Again, it is important to note that, by itself, loss of blood flow with the arm elevated in different positions is not diagnostic of ATOS.

CT Angiogram/MR Angiogram of the Chest (CTA or MRA) this is a CT scan or MRI of the chest which can show the vessels particularly the axillary-subclavian vein and axillary-subclavian artery. This is also sometimes referred to as an arteriogram. These tests involve injecting contrast material and taking x-ray images to determine how the blood moves through the artery, the exact location of the artery compression, and to see what physical condition the artery is in as far as damage, clot, or aneurysm. Either test can be performed both with the arm up and with the arm down. Again, by itself, compression of the artery with the arm elevated is not diagnostic of ATOS.

Catheter-Directed Angiogram This is typically only done to assess the smaller arteries lower down in the arm if clots in those arteries are suspected to have traveled down from the axillary-subclavian artery. Thrombolysis can be performed to break up those clots. This procedure is usually performed by a vascular surgeon or an interventional radiologist. Often, the patient is given mild sedation. It involves inserting a needle or sheath into an artery on the affected arm. A catheter will be inserted into the artery, contrast dye will be injected into the artery, and x-ray images will be taken to assess blood flow and condition of the artery. Depending on the findings on the images, during the same procedure, this same catheter can be used to reach and try to break through any clot(s) and/or to administer medication to the area of any clot(s) to help dissolve it.

Radiology (X-Ray Imaging)

There is no plain radiology test that will show ATOS. Therefore, most x-ray imaging is done to look for bony abnormalities that are typically present in patients with ATOS.

Plain Chest X-Ray can be done to look for any anatomical abnormalities such as anomalous first rib, rib fracture, cervical rib, or collarbone fracture.

Plain Cervical Spine (Neck) X-Ray can be done to look for cervical ribs or elongated C7 transverse processes. Most radiologists are not looking for cervical ribs or elongated C7 transverse processes as they are typically incidental findings and most people who have them do not experience symptoms or develop any conditions related to them. Even if a radiologist does see them, they often leave them out of the radiology report for the same reasons. If a patient is having this x-ray specifically to help with diagnosis of ATOS, they should request that the ordering physician state that the purpose of the imaging is to look for cervical ribs. However, the presence of cervical ribs alone is not diagnostic of ATOS. Although most ATOS patients do have a cervical rib or other bony abnormality, it does not mean that everyone with a cervical rib has or will develop ATOS.

Cervical Spine (Neck) CT Scan in rare instances, if plain x-rays are not showing a cervical rib or other bony abnormality but suspicion is high, a CT scan can be done to help identify them.

PROVOCATIVE MANEUVER TESTING

Provocative maneuver testing is tests involving different arm and/or head & neck movements (maneuvers) which are intended to trigger (provoke) certain symptoms. In general, the accuracy of provocative maneuver testing for ATOS is fairly low. The tests have a fairly high false positive rate, which means that they identify a lot of people as having ATOS when they, in fact, do not. Diagnosis of ATOS should not be made based only on a positive provocative maneuver test. Negative provocative maneuver testing cannot rule out ATOS. The provocative maneuver tests done for ATOS are designed to assess positional artery compression where loss of pulse is triggered by certain neck and elevated arm movements. The two most common tests are the Adson's Test and Wright's Test but there is also Eden's Test and the Costoclavicular Maneuver. All of which are considered to be positive if there is loss of radial pulse. As has been noted several times on this page, loss of blood flow with the arm elevated in different positions, by itself, is **not** diagnostic of ATOS. What these tests can do is assess what symptoms are triggered by the arm being in certain positions which might help support a diagnosis of ATOS.

Adson's Test this tests the radial pulse with the arm and head/neck in a certain position. The arm is kept low but held out to the side of the body and pulled back a little bit. The patient takes a deep breath and holds it and then elevates the chin and turns the head

toward the affected side. A significant decrease or complete loss of pulse is considered positive.

Wright's Test this tests the radial pulse with the arm in a certain position. The arm is held up in a "surrender" position for 1 minute while the radial pulse is tested. Then the arm is put all the way up next to the head while the radial pulse is tested. A significant decrease or complete loss of pulse is considered positive.

Eden's Test – aka Military Brace Test this tests the radial pulse with the arm and shoulder in a certain position. It involves sitting straight like in a military position with the chest pushed out and the shoulders pulled back for 1 minute. A significant decrease or complete loss of pulse is considered positive.

Costoclavicular Maneuver – aka Exaggerated Military Brace Test this tests the radial pulse with the arm and shoulder in certain positions. It involves the patient sitting while the examiner assists the patient in performing the following 4 movements: scapula retraction, scapula depression, elevation, and protraction holding each position for up to 30 seconds, while the patient rests his or her forearms on his thighs. A significant decrease or complete loss of pulse is considered positive.

PUBLISHED DIAGNOSTIC CRITERIA

In 2016, the top TOS specialists in the United States collaborated to come up with standardized diagnostic criteria for all 3 types of TOS. It was published in an article in the Journal of the Society for Vascular Surgery. Below are the published standardized criteria for the diagnosis of ATOS.

Definitions and diagnostic criteria. ATOS is defined as an objective abnormality of the subclavian artery caused by extrinsic compression and subsequent damage by an anomalous first rib or analogous abnormal structure (cervical rib or band) at the base of the scalene triangle. Such an abnormality can be symptomatic (ischemia or embolization) or asymptomatic (aneurysm, occlusion, or silent embolization). Loss of pulses or discoloration with provocative maneuvers in patients with NTOS does *not* mean that ATOS is present; documented injury to the subclavian artery or symptomatic arm ischemia with arms elevated must be present for this diagnosis to be made.

Illig KA, Donahue D, Duncan A, Freischlag J, Gelabert H, Johansen K, Jordan S, Sanders R, Thompson R. Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome. J Vasc Surg. 2016 Sep;64(3):e23-35.

TREATMENT

General

All TOS experts agree that surgical treatment is a necessity for ATOS. The majority of conservative (non-surgical) treatment is done in addition to surgery either to prevent further clotting while waiting for surgery or to make surgery more easily accomplished and more successful. Occasionally, there can be certain situations in which a patient might have a medical condition or circumstance which renders surgery not an option, but in general, it is always recommended. In the case of an arterial blood clot, the clot can travel and end up in smaller arteries down lower in the arm, hand, and fingers. If not treated very quickly and

properly, this puts various parts of the arm and even the entire arm in danger of not having blood flow (ischemia) which is a condition that can result in loss of fingers, the hand, or the arm. Rarely, a clot can travel in the opposite direction of the blood flow and travel backwards getting into the vertebral artery which supplies the brain with blood. When this happens, it can lead to a stroke. Although exceedingly rare, in the case of an arterial aneurysm rupture, it can result in massive hemorrhage which can be life threatening if not treated emergently and properly.

CONSERVATIVE TREATMENT (NON-SURGICAL OR PRE-SURGICAL)

Anticoagulation (Blood Thinners)

Almost all TOS experts agree that once a patient has been definitively diagnosed with ATOS, blood thinner medication should begin immediately. This is typically in the form of an injection or an oral medication, but sometimes it is via IV infusion depending on the circumstances. Sometimes both anticoagulants and antiplatelets are administered. The main goals of blood thinners with respect to ATOS are to:

- Prevent the clot from embolizing and traveling to other arteries
- Prevent further clots from forming

Blood thinners are only meant to be an interim treatment until the patient can have surgery. Because ATOS blood clots are caused by extrinsic (external) compression of the artery by the cervical or first rib and other structures, clots can still occur despite being on blood thinners.

Thrombolysis (Breaking Up/Dissolving the Clot)

Thrombolysis in the scenario of ATOS is typically only used for clots that have traveled to smaller arteries lower down in the arm. It involves inserting a needle or sheath into an artery on the affected arm. A catheter is then inserted into the artery and is slowly guided through the artery until it reaches the location of the clot. Thrombolysis can be done in a few different ways. One way is to use medication only. This involves continuous infusion of medication to dissolve the clot via the catheter that was inserted into the artery next to the clot. This is usually done over 24-48 hours and requires hospitalization to be monitored in the ICU. The other way to accomplish thrombolysis is by a combination of medication to dissolve the clot and a mechanical device on the tip of the catheter to physically break up the clot. This can usually be achieved in a matter of hours and typically does not require overnight hospitalization.

Experts have found that thrombolysis is typically only successful if performed within the first 14 days of the formation of the blood clot. Therefore, it should only be performed if the clot is acute and within this window of time. Most experts believe that thrombolysis should only be performed on a patient who is in the early stages of arm ischemia whose risk of losing the arm is on the lower end as it requires a more lengthy process to restore blood flow to the arm. Otherwise, in a case where a patient has more severe ischemia and whose risk of losing the arm is higher, experts believe that the patient should be taken to the OR for thromboembolectomy to surgically remove any clots within the arteries of the arm to restore blood flow. However, some experts believe that surgically removing the clot(s) is the preferred method no matter the severity of the patient's arm ischemia. Depending on the circumstances, thrombolysis and/or thromboembolectomy is sometimes done at the same time as decompression surgery as opposed to before it.

Stents

Placing stents inside vessels to help them remain open is commonplace for narrowed vessels in other parts of the body and under different circumstances. However, all TOS experts agree that stents should **not** be placed into the axillary-subclavian artery prior to surgery. Because the arterial narrowing in the case of ATOS is caused by external compression of the artery by the cervical or first rib and other structures, failure or fracture of the stent is almost guaranteed. If this occurs, it can lead to further clotting and pain, and can also make future surgical treatment much more difficult.

SURGICAL TREATMENT

Surgery is the mainstay of treatment for ATOS. Since, by definition, ATOS involves a clot or arterial damage/abnormality, it is the only definitive long-term treatment. If the mechanical compression that is compressing the artery is not removed, the patient risks developing further clots (even if on blood thinners) and permanently damaging the artery leading to possible life or limb threatening conditions. As with any type of TOS, the surgery is extremely complicated and takes place in a very complex area of the body where several vital structures are all packed tightly together in a very small space. In the case of ATOS in particular, it can be even more technically challenging and risky especially if artery reconstruction is required. With a surgeon who is **not** experienced in TOS surgery, damage to vital vessels and to nerves that serve the arm and hand can occur and can be devastating. Therefore, of the surgeons available to a patient, it is recommended to choose the surgeon who has the highest level of TOS experience possible. There are very few dedicated TOS centers in the United States and even fewer throughout the rest of the world. Because of this, many patients must travel to other states or other countries for experienced care. However, choosing a highly experienced TOS surgeon gives the patient the highest chance for a successful outcome and the lowest chance for serious complications. Under these circumstances, TOS surgery can be very safe and successful. For help finding a TOS surgeon, go to www.tosoutreach.com/find-a-surgeon. In addition, it is important to note that not all ATOS surgery is an emergency. It is typically only an emergency in the extremely rare circumstance where an aneurysm has ruptured or if the patient has significant arm ischemia from lack of blood flow and even then, once surgical removal of the clot(s) has taken place, there is usually still time to find an experienced TOS surgeon to perform the thoracic outlet decompression surgery with possible artery repair or reconstruction. In situations where the patient only has a small aneurysm or post-stenotic dilatation, surgery can be performed on an elective basis with plenty of time to be referred to an experienced TOS surgeon, if possible.

What does surgery for ATOS entail?

In general terms, ATOS surgery is often referred to as thoracic outlet decompression surgery as it involves removing anatomical structures and scar tissue in order to decompress the artery. ATOS surgery usually involves of hospital stay of 2-6 nights depending on what was done during surgery. The main goals of ATOS surgery are (1) to decompress the artery to prevent any further damage or blood clots, (2) to restore and maintain normal blood flow through the axillary-subclavian artery, and (3) to restore and maintain blood flow through smaller arteries lower down in the arm. There are actually several components to ATOS surgery. Depending on the patient's findings and the surgeon's protocol and experience level, ATOS surgery includes some or all of the following:

- Removal of the first rib known as First Rib Resection (complete or partial)
- Removal of cervical rib, if present, known as Cervical Rib Resection (complete or partial)

- Removal of the anterior scalene muscle known as Anterior Scalenectomy (complete or partial)
- Removal of the middle scalene muscle known as Middle Scalenectomy (complete or partial)
- Removal of scar tissue from around the nerves known as Brachial Plexus Neurolysis (complete or partial)
- Removal of scar tissue from around the artery known as Arteriolysis (complete or partial)
- Intraoperative Arteriogram or Intravascular Ultrasound
- Artery reconstruction
- Thrombolysis or Thromboembolectomy

Most TOS experts believe that, at a minimum, removing the first rib, cervical rib, and most or all of the anterior scalene, in addition to performing arteriolysis is the best way to achieve a complete and thorough decompression and to prevent recurrence of ATOS. Most TOS experts also agree that, in the case of clots, a certain size aneurysm, or certain damage to the artery, arterial repair or reconstruction is required. There are also several different surgical approaches to take, and each of them allows for different variations in treatment. Also, because TOS is not a well-known condition and surgery for it is not regularly performed by most surgeons, there exists a wide variety of surgical component combinations that can be performed for ATOS. For this reason, let's break each component down a little further:

Removal of the first rib known as First Rib Resection (complete or partial) As far as history goes, removing the first rib is probably the oldest and most common component of TOS decompression surgery. Some surgeons believe that removal of only the cervical rib is enough for ATOS, but most TOS experts believe that, for most ATOS patients, all or part of the first rib should be removed in addition to the cervical rib. Complete removal of the entire first rib helps to decompress the nerves and both vessels of the thoracic outlet. However, when the artery is the only structure that needs decompressing, as is usually the case with ATOS, then typically only the back ¾ (approx.) of the first rib needs to be removed. This is often referred to as the posterior portion of the first rib. Essentially, cutting the rib at the point directly in front of where the anterior scalene muscle attaches to it and removing it from that point all the way back to where the rib attaches to the spine should suffice. Most TOS experts agree that removing any less of the first rib can be problematic as complete decompression of the artery might not be achieved. This is especially true in the case of an anomalous first rib. In addition to not achieving complete decompression of the artery, some TOS experts have also seen that any amount of posterior rib that is left behind can become an attachment point for post-surgical scar tissue. If scar tissue attaches to the remaining rib, it can compress the artery again and result in a return of symptoms. This scar tissue attached to the remaining rib can also compress the brachial plexus nerves resulting in post op development of secondary NTOS. Therefore, removal of the first rib can be a twofold component of ATOS surgery – (1) decompressing the artery and (2) preventing recurrence and secondary NTOS if scar tissue forms.

Removal of cervical rib, if present, known as Cervical Rib Resection (complete or partial) a cervical rib is almost always involved in axillary-subclavian artery compression. Most TOS experts will remove the cervical rib in addition to the first rib. It is usually removed in its entirety. However, certain surgical approaches can limit access to the entire cervical rib and thus partial removal might only be possible. As with the first rib, this might not achieve complete decompression, and can also be a risk to become a scar tissue attachment point which can compress the artery again and result in return of symptoms or compress the nerves leading to the development of secondary NTOS.

Removal of the anterior scalene muscle known as Anterior Scalenectomy (complete or partial) because the anterior scalene is attached to the first rib, in order to remove the first rib, it must, at a minimum, be detached from the first rib. Whether it also gets removed either partially or completely is up to the surgeon. Detaching the anterior scalene from the rib but **not** removing it is called anterior scalenotomy. Almost all TOS experts agree that either some or all of the anterior scalene muscle should be removed for purposes of complete decompression of the artery. In addition, some surgical approaches limit access to be able to remove the entire anterior scalene muscle. One potential issue with a partial anterior scalenectomy or anterior scalenotomy is that there is a chance for the remaining part of the scalene to reattach to other structures and cause recurrent artery compression and/or cause compression of the brachial plexus nerves resulting in development of secondary NTOS. This has been a consistent finding during reoperations on patients who had either prior partial anterior scalenectomy or anterior scalenotomy.

Removal of the middle scalene muscle known as Middle Scalenectomy (complete or partial) because the middle scalene is attached to the first rib, in order to remove the first rib, it must, at a minimum, be detached from the first rib. Whether it also gets removed either partially or completely is up to the surgeon. Detaching the middle scalene from the rib but **not** removing it is called a middle scalenotomy. The middle scalene can sometimes play a part in axillary-subclavian artery compression, but some TOS experts believe that it is unnecessary to remove the middle scalene at all and that simply detaching it from the first rib in order to remove the first rib is all that is needed. In addition, some surgical approaches limit access to be able to remove the entire middle scalene muscle. Other TOS experts believe that the middle scalene muscle should be removed particularly due to the fact that there is a chance for the remaining part of the scalene to reattach to other structures and cause recurrent artery compression and/or compression of the brachial plexus nerves resulting in development of secondary NTOS. This has been a consistent finding during reoperations on patients who had either prior partial middle scalenectomy or middle scalenotomy.

Removal of scar tissue from around the nerves known as Brachial Plexus Neurolysis (complete or partial) even though a patient might be primarily undergoing surgery for artery compression, it is not uncommon for these patients to also have some level of scar tissue around the brachial plexus nerves as the nerves and artery are right next to each other. Most TOS experts will go ahead and perform neurolysis if they notice scar tissue around the nerves during surgery. Some surgical approaches for ATOS allow access for a complete neurolysis of all 5 brachial plexus nerve roots and some only allow access for neurolysis of the lower 3 nerve roots. Some experts believe that leaving any scar tissue around the nerves would not constitute a full decompression and could therefore continue to cause symptoms.

Removal of scar tissue from around the artery known as Arteriolysis (complete or partial) almost all TOS experts agree that arteriolysis of the artery should be done for complete decompression. However, some experts believe that certain surgical approaches allow for a more complete external arteriolysis than others, and removal of all scar tissue from around the artery is critical to achieving complete decompression especially if no artery reconstruction is needed.

> **NOTE: Most TOS experts agree that some type of artery repair or reconstruction is required if the dilated section of the artery is more than twice the size of the artery's normal size, if there are clots that have traveled to smaller arteries lower down in the arm, or if there is excessive damage or certain abnormalities within the artery. There are various options for repair and reconstruction of the artery. Below are descriptions of the components of ATOS surgery related to this issue.**

Intraoperative Arteriogram or Intravascular Ultrasound some, but not all TOS experts, perform an arteriogram during surgery. Some will use it following the decompression part of surgery to determine whether the axillary-subclavian artery has internal damage or abnormalities that would warrant artery repair or reconstruction. Intravascular ultrasound can also be used for this purpose. Arteriogram can also be done to assess for clots in the smaller arteries lower down in the arm to determine whether thrombolysis or thromboembolectomy is necessary to restore blood flow to those arteries. Arteriogram can also be done at the end of surgery to determine whether any thrombolysis or thromboembolectomy was successful in restoring blood flow to the smaller arteries.

Artery Repair or Reconstruction most TOS experts agree that if the artery is too damaged or has severe wall abnormalities, then repair or reconstruction of the artery is required. Only certain surgical approaches allow for artery reconstruction. Depending on the surgeon's knowledge and familiarity with performing specific aspects of TOS surgery with a certain surgical approach, more than 1 surgical approach might be used for ATOS surgery with reconstruction. There are several different options for artery repair and reconstruction. Which option is used can depend on the type of arterial damage, how much of the artery is damaged, and the location of the damaged area. The most common options are:

- Primary Repair – the damage section of the artery is removed and the 2 remaining ends of the artery are sewn together.
- Bypass Graft – removing the damaged section of the artery and replacing it with donor or synthetic material

Most experts will perform decompression and reconstruction in the same surgery. However, if repairing or reconstructing the artery was not addressed during the original decompression surgery, it can be done later in a separate surgery.

Thrombolysis or Thromboembolectomy if clots in the smaller arteries lower down in the arm (distal arteries) were not addressed separately prior to decompression and reconstruction surgery, they can be addressed during it. This can be done with thrombolysis, by surgically removing the clots, or by a combination of both. In some cases, if the clots in these arteries are old and scarred and have caused damage to the artery, bypass reconstruction might be required to restore blood flow.

As with any surgery, the decision to have surgery and which components should be included in said surgery should be made based on advice given by the patient's surgeon as to what is best for their specific clinical situation.

ATOS Surgery Recovery

In general, the post-hospital recovery for ATOS surgery is usually fairly straightforward. Of course, this can depend on what exactly was done during surgery and what complications occurred. Below is a list of expectations following ATOS surgery keeping in mind that every recovery is different and not everyone will experience the things listed.

- Can include continuing to experience pre-op symptoms such as arm/hand numbness, tingling, color changes, temperature changes or pain
- new symptoms can be felt in the neck, chest, upper back, shoulder, arm, or hand
- because nerves usually have to be manipulated during surgery and some patients also require brachial plexus neurolysis, some experience nerve symptoms from surgery such as numbness, tingling, pain, burning, skin hypersensitivity, itching, stinging, electrical zaps, cold sensations, hot sensations, skin color and temperature changes, muscle twitching, neck and upper back muscle tightness

- nerve symptoms are usually very temporary only lasting a few weeks depending on how involved the nerves were in the compression and how much scar tissue was removed
- Some loss of arm strength and range of motion. Although, some can have full range of motion immediately after surgery, most have some degree of diminished strength and range of motion
- Low energy and general fatigue with activity. For some, this can last for a few months.
- Remaining on blood thinners for anywhere from 6 weeks to 6 months post op or sometimes longer depending on the circumstances and post-op course
- Most do PT to regain arm strength and range of motion
- Most are fully healed after 3-6 months

Restrictions

- Most return to work anywhere from 4-12 weeks post op depending on how physically demanding the job is
- Most have weight restrictions of no more than 5-10 lbs for at least 4-12 weeks. This usually includes lifting, pushing, pulling, etc.
- Most have activity restrictions including no overhead or above shoulder activity and nothing repetitive for at least 4-12 weeks
- Most are able to return to driving by 4 weeks post op
- Restrictions are at the discretion of the surgeon as to when they are imposed and when they are lifted.

Return of Symptoms (Recurrent ATOS)

Sometimes a patient will experience initial relief and then have symptoms return. The two most likely causes for a recurrence of ATOS symptoms are:

Complete decompression not achieved during surgery this would occur as described earlier on this page when some anatomy, usually rib or scalene muscle, was either not removed at all or only partially removed.

No, reoccluded or failed Artery Repair or Reconstruction this would occur when a patient whose artery is damaged or seriously abnormal did not have artery repair or reconstruction performed, had unsuccessful artery repair or reconstruction, or had artery repair or reconstruction which reoccluded.

Secondary NTOS

Sometimes a patient who has ATOS which was successfully treated with surgery will begin to experience symptoms of NTOS sometime after surgery. As described earlier on this page, this can occur when the first rib is not removed, when too much of the posterior portion of the rib is left in, when too much of the cervical rib is left in, or when there is incomplete anterior and/or middle scalenectomy.

For more information on all types of TOS including symptoms, diagnosis, treatment, and more, please visit www.TOSOutreach.com.