CLINICAL PRACTICE

Strabismus Surgery Complications: Prevention and Management

SCOTT A. LARSON, MD, DAVID B. PETERSEN, MD, AND WILLIAM E. SCOTT, MD

Abstract. Strabismus surgery is increasingly becoming a subspecialty domain, especially with cyclovertical muscles, restricted muscles, or reoperations. While is impossible to completely eliminate complications from strabimus surgery, it is possible to minimize their occurrence and significance by proper prevention and management. In general, the best policy for avoiding poor outcomes from complicated surgery is to perform procedures only for which one has been fully trained and has the necessary experience. This update will describe intraoperative and postoperative complications of strabismus surgery, emphasizing their prevention and management. **(Comp Ophthalmol Update 4: 255-63, 2003)**

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Dr. Larson is assistant professor of ophthalmology, John Moran Eye Center, University of Utah, Salt Lake City, UT. Dr. Petersen is a pediatric ophthalmologist in private practice, Salt Lake City, UT. Dr. Scott is emeritus professor of ophthalmology, University of Iowa, Iowa City, IA.

Reprint address:
Scott A. Larson, MD, John Moran Eye Center, University of Utah, 50 N. Medical Dr., Salt Lake City, UT.
email:Scott.A.Larson@hsc.utah.edu

In order to provide the highest standard of care, a surgeon must understand the possible complications of any procedure that he or she would perform. It is impossible to completely eliminate complications from surgery, but it is possible to minimize their occurrence and significance by proper prevention and management. In general, the best policy for avoiding poor outcomes from complicated surgery is to perform only procedures for which one has been fully trained and has the necessary experience. Strabismus surgery is increasingly becoming a subspecialty domain, especially with cyclovertical muscles, restricted muscles, or reoperations. For those who do undertake surgery on the extraocular muscles, this update will describe intraoperative and postoperative complications, emphasizing their prevention and management.

Intraoperative Ocular Complications

WRONG SITE SURGERY

Recent events at Duke University Medical Center have again brought medical errors into the public eye.[1] The Joint Commission on Accreditation of Healthcare Organizations tracks wrong site surgery as a reportable sentinel event.[2] This can include operating on the wrong patient, the wrong eye, the wrong extraocular muscle, or performing the wrong surgery on the correct muscle, such as performing a resection when a recession was intended. The symmetry of the globe and its ease of rota-

tion make it possible to become disoriented and perform the procedure on the wrong muscle.

Prevention is clearly the most important factor in these cases, with meticulous attention to the surgical plan and surgical technique. If globe rotation is suspected, it is very helpful to remove all instruments, allow the globe to come to its resting position, and start again. Looking at the fundus with indirect ophthalmoscopy can confirm suspected torsion. On a lesser scale, one may hook only part of the intended muscle or include an unintended muscle in the surgery, such as the inferior oblique when operating on the lateral rectus. Management of an error, if it does occur, requires full, honest disclosure to the patient, as well as further surgical intervention or referral for correction of the problem.[3]

SLIPPED, LOST, OR TORN MUSCLES

A slipped or lost muscle can result in significant postoperative misalignment. A muscle slips when inadequate muscle tissue is included in the suture or lock bites, or, more rarely, when a thin scleral tunnel tears through or the knot unties. The muscle then retracts back into the capsule, which remains attached to the globe. If the capsule also comes free from the globe, a lost muscle has occurred. Rarely a muscle will pull-on-two with traction by a muscle hook.[28] Usually the root cause is an underlying systemic disease such as myotonic dystrophy or reoperation of an atrophic muscle in an elderly patient.[29,30] Prevention is centered on secure lock bites, scleral tunnels, and knots. Management varies according to the specific situation. If a muscle begins to slip intraoperatively, immediately grasp it with whatever forceps are available. If it is lost completely from view, hydrating the cut end or using a hand-over-hand technique to pull tissue forward is often successful. Postoperatively, slipped muscles are evident by poor ductions in the field of the operated muscle along with a large misalignment in the primary position. Usually, a preoperative computed tomography (CT) or magnetic resonance imaging of the orbit is helpful in defining the anatomy.[31] Surgery is often done under high magnification with an operating microscope and a qualified assistant.[32] Specialized techniques such as use of an electric muscle stimulator or a transnasal endoscopic approach may be necessary.[33] Success rates can be quite good after such treatments.

Focus Point #1

Scleral perforation occurs in about one in 100 muscle surgeries. A high index of suspicion is needed to avoid further complications when perforations occur.

Focus Point #2

The oculocardiac reflex can result in cardiac arrest. Avoid excessive pulling on the extraocular muscles.

OCULAR PERFORATIONS

The most feared complication of strabismus surgery is scleral perforation, leading to retinal detachment, endophthalmitis, or blindness. The reported incidence with modern surgical techniques is between 0.4% and 1.8% per muscle and between 1.2% and 2.8% per patient.[34-36] This includes all recognized and unrecognized perforations found by thorough perioperative indented ophthalmoscopy. Risk factors include myopia, previous strabismus surgery, surgeon inexperience, and possibly posterior fixation sutures.[37-39] The vast majority of perforations occur during muscle reattachment, but they may occur at any step of the procedure. Perforation leads to retinal detachment in approximately 2% of cases, endophthalmitis in 0.5%, and other complications even less often.[42-48]

Endophthalmitis following strabismus surgery often progresses to phthisis bulbi, but cases of good outcome have been reported.[49-52] Often a perforation was not recognized at the time of surgery. Endophthalmitis usually develops within 4–7 days after surgery, and presents with lethargy, asymmetric eye redness, chemosis, eyelid swelling, or fever.[53] The risk of partial or total vision loss following recognized scleral perforation is estimated to be 1.2%.[38]

Prevention of ocular perforation begins with identifying the risk factors. Good exposure, the use of magnification with loupes or a microscope, and the use of fine spatulated needles with 6-0 suture passed only within the sclera are essential. Hangback sutures and muscle tucks instead of standard procedures can be considered if direct suturing to the sclera is dangerous. Management of scleral perforations begins with indirect ophthalmoscopy in all suspected cases. If a perforation is found through the retina, cryotherapy or laser treatment has been traditionally used.[40] More recently, some authors cautiously recommend close observation alone.[41] An often-cited rabbit study may support observation in scleral perforation.[54] We recommend the use of subconjunctival antibiotics and close follow-up in these cases.

Nonocular Complications

OCULOCARDIAC REFLEX

The oculocardiac reflex occurs when stretch on an extraocular muscle leads to a vaso-vagal response, usually bradycardia. Often called the five-and-dime reflex, the oculocardiac reflex results from the interaction of the afferent fifth (trigeminal) and efferent tenth (vagal)

cranial nerves. The reported incidence ranges from 13% to 68%.[4,5] It can occur with any of the extraocular muscles but is more common with the medial or inferior rectus, and in patients of any age, although it occurs more commonly in children.[6,7] Prevention includes gentle surgical technique to minimize the response.[6] Blocking vagal output with atropine or glycopyrrolate is also very effective.[8] Management usually involves nothing more than relaxing the tension on the inciting muscle until the heart rate normalizes. However, the oculocardiac reflex has been reported to result in cardiac arrest and even death.[9-12] Overall, the reported mortality rate of pediatric strabismus surgery is 1.1 per 10,000 operations.[13]

MALIGNANT HYPERTHERMIA

Malignant hyperthermia is an autosomal dominant inherited disorder, and is one of the most common causes of anesthesia-related death in young patients (incidence ranging from 1:15,000 to 1:50,000).[14] It can occur at any age between 2 months old and 78 years old, and it is more common in children. Dodd et al published a case report with an excellent review of this topic as it relates to strabismus surgery.[15] Prevention involves asking all patients about a family history of reactions to anesthesia prior to surgery. Management is centered on early recognition and intervention. The most common early signs are unexplained tachycardia, masseter rigidity, and hyperthermia. Once malignant hyperthermia is recognized, treatment consists of discontinuing the anesthesia immediately and aborting the surgery. Body temperature, acidosis, and electrolyte balance are monitored and corrected. Dantrolene 1.0–10.0 mg/kg are given intravenously. Urine output must be monitored to prevent renal failure from myoglobinuria. Overnight observation in the intensive care unit is warranted. If unrecognized, malignant hyperthermia can lead to pulmonary edema, arrhythmia, cardiac arrest, and death.[16] Currently, the mortality is estimated to be less than 10%, due to greater awareness and effective therapies. If recognized and treated within 15 minutes of onset, mortality is essentially zero. The surgery can be successfully carried out at a later date using narcotic anesthesic and nondepolarizing muscle relaxants.

NASAL SECRETIONS

Anesthesia-induced nasal secretions may contaminate the surgical field. Propofol has been implicated in inducing hypersecretion.[17] It is more common in adults and in prolonged procedures. The reported incidence of nasal secretions into the operative field is as high as 5% in ophthalmic surgical cases under general anesthesia.[18] Prevention involves proper postioning of the patient and draping the patient with a sealed plastic drape around the lower lids. Premedication with glycopyrrolate should be considered in prolonged cases. Management involves immediately staunching the flow of secretions before they reach the eye, removing the saturated drapes, reapplying sterile drapes, and considering oral antibiotics postoperatively.

NAUSEA

Postanesthesia nausea and vomiting are very common following strabismus surgery, with a reported incidence ranging from 33% to 85%.[19,20] It is clearly linked to the oculocardiac reflex, and similarly it is more common in children.[6, 21] Nausea and vomiting may delay postoperative discharge, and they can be especially troubling with postoperative suture adjustments.[22,23] An extensive body of work in the anesthesia literature exists regarding the control of postanesthesia nausea and vomiting, and it is beyond the scope of this update.

Prevention is guided by the anesthesiologist selecting the current proper agents.[24,25] Management can be effectively carried out with droperidol or metoclopramide, and has been more recently described with ondansetron.[26, 27]

Postoperative Complications

OVERCORRECTIONS AND UNDERCORRECTIONS

Over- or undercorrections are the most common complication of strabismus surgery. There is no definite standard for defining a successful strabismus surgical outcome. Many define success in terms of motor alignment within 10 prism diopters of orthotropia, while stricter criteria demand evidence of sensory fusion. Studies have reported rates of surgical overcorrections to be anywhere from 3%–38%.[55-61] Intentional early postoperative overcorrection is the goal of some strabismus surgeons.[62,63] Therefore, a small overcorrection in the early postoperative period would not be considered a complication unless it persisted.

Undercorrection is more common than overcorrection, especially in congenital esotropia, and it is a common reason to perform a reoperation.[55,56,64] The reoperation rate due to undercorrections in one large study was 14% for congenital esotropia and 5% for acquired esotropia.[64] Some surgeons operate on three or four horizontal rectus muscles for angles over 55 prism diopters. Overcorrections tend to drift toward orthotropia but undercorrections will rarely, if ever, correct themselves and might need reoperation sooner.

The prevention of over- and undercorrections includes accurate measurement of the preoperative angle of strabismus, accurate dosing of surgery, accurate intraoperative measurement, preoperative prism adaptation, and the use of adjustable sutures.

First, accurate measurements are essential. Two different measurements that coincide by 5 prism diopters is ideal. If there is variability, a third or fourth measurement done over a period of weeks to months might be required. The inherent difficulty in measuring very young children could partially explain the higher rates of over- and undercorrection seen in congenital esotropia.

Secondly, the dose of surgery to administer is also important. In order to determine the amount of recession or resection to perform, many beginning or occasional strabismus surgeons use surgical dose tables provided by empiric data.[65,66] The use of these surgical tables when appropriately applied will provide good surgical results. With more experience, the individual surgeon can tailor the amount of recession or resection to perform based on his or her own experience.

Third, the measurement of the position of the muscle before disinsertion and the position it will be sewn onto the sclera must be accurate. To ensure proper position of a muscle, a curved ruler or caliper should be used. A curved ruler is more accurate for measuring along the surface of the globe in large recessions.[67] Recording these measurements in the operative record will facilitate a reoperation if it becomes necessary.

Fourth, preoperative prism adaptation has been shown to increase surgical success without increasing the number of overcorrections in a randomized prospective trial in children with acquired nonaccomodative esotropia.[68,69]

Finally, adjustable sutures improve success and avoid over- or undercorrections. The technique has been described at length in the literature.[70] One large retrospective study that included complex strabismus cases with restriction and paresis found that about half of the patients required adjustment because of unsatisfactory postoperative alignment.[71] Overall, 70% achieved a satisfactory alignment. The adjustable suture technique may be most useful in vertical and complicated incomittant deviations that require precise alignment for fusion.

Focus Point #3

Over- or undercorrection is the most likely complication to occur after strabismus surgery.

Focus Point #4

Orbital cellulitis is uncommon after strabismus surgery but if suspected a broad-spectrum antibiotic should be instituted.

ORBITAL CELLULITIS

Thankfully, infections following strabismus surgery are rare. The estimated incidence of cellulitis following strabismus surgery is one in 1,900.[44,72,73] Prompt recognition of the signs of infection and appropriate treatment are critical. The first morning after surgery the conjunctiva will be the most swollen and edematous. Warning patients of this fact will avoid unwanted phone calls and worries. The swelling, redness, and discomfort should continue to improve from that point onward. Postoperative pain is usually no more than mild discomfort. Any severe pain could be a sign of infection. Many strabismus surgeons see their patients within the first postoperative week to monitor for infection. Usually infection presents within the first 3–4 days after surgery.

Prevention may include prophylactic postoperative topical antibiotic or antibiotic and steroid combination drops. Some use preoperative prophylactic antibiotics topically. Others use oral or subconjunctival antibiotics and still others use no antibiotic at all.[44] Given the low incidence of infections, no specific recommendations or standard of care concerning antibiotics has been established.

The typical signs and symptoms of orbital cellulitis include pain, sensitivity to light, proptosis, periorbital swelling, erythema, ptosis, motility restriction, fever, and leukocytosis. The majority of cases reported are from school-aged children. The most common causative organism is *Staphylococcus aureus*.[73] If cellulitis is suspected, a broad-spectrum antibiotic should be instituted. An oral antibiotic can be used for mild cases but severe cases require broad-spectrum intravenous antibiotics. An orbital CT should be considered to evaluate for orbital abcess. There have not been any reports of vision or life-threatening infections since CT scanning has become available.

ANTERIOR SEGMENT ISCHEMIA

Ischemia of the anterior segment occurs most often after surgery on three or all four rectus muscles. The anterior ciliary vessels, which supply the anterior segment, travel through the rectus muscles. Flourescein iris angiography has been done on patients before and after tenotomy of the rectus muscles.[74] Detaching the two vertical and the lateral rectus significantly interrupts anterior segment blood flow. Patients who have had previous strabismus or retinal surgery, elderly, atherosclerosis, blood dyscrasias, occlusive carotid artery disease, or thyroid ophthalmopathy are at increased risk. The incidence of anterior segment ischemia is estimated at one in 13,000 cases.[75] It is extremely uncommon in children because of their ability to better develop collateral circulation.

Anterior segment ischemia has a broad range of manifestations from mild anterior segment inflammation to full-blown phthisis. The symptoms include pain and decreased vision in the first 24–48 hours after surgery.

Most commonly the eye becomes hypotensive and the anterior segment cell and flare are seen in conjunction with a poorly reactive, segmentally unreactive, and ectopic pupil. Mild to severe corneal edema and corneal ulceration may be present. Later in the course, posterior synechaie, iris rubeosis, segmental or generalized iris atrophy, glaucoma, cataract, and hypotony can develop. Most patients recover vision and their pain resolves gradually in the 2–8 weeks after surgery.

Prevention is aimed at identifying those at risk, limiting the number of rectus muscles operated, and staging procedures if necessary to allow for collateral blood flow to develop. It can take from 6 weeks to 6 months for collateral circulation to develop. Preserving the anterior segment circulation by meticulous microsurgical dissection of the vessels from the underlying muscle and tendon has been used successfully to avoid interruption of circulation and avoid ischemia.[76]

Many treat this condition with topical or systemic steroids in combination with cycloplegic agents. There is no evidence however that treatment improves the outcome. Many do not treat anterior segment ischemia at all.

CONJUNCTIVAL CYSTS AND TENON'S CAPSULE PROLAPSE

Subconjunctival cysts can develop after strabismus surgery from improper closure of the conjunctival surface.[77] Care should be taken to incorporate the conjunctival edge and not allow the tissue to roll under and trap conjunctiva under the surface. If a cyst develops, resection is the most effective treatment. Aspiration of the cyst contents will invariably result in recurrence.

Occasionally, redundant Tenon's capsule prolapses through a conjunctival wound postoperatively. If the conjunctiva is not closed, there is an increased risk of Tenon's capsule prolapse through the wound. This usually is not a problem because the conjunctiva will eventually close over the exposed Tenon's capsule. However, the delay in wound closure puts the tissue at a higher risk of infection., Additionally, the exposed Tenon's capsule is often unsightly to the patient or family. If the Tenon's capsule readily prolapses through the incision, the redundant tissue should be excised. Preferably this is recognized while still in the operative suite. In adults and older children, prolapsed Tenon's capsule can be easily excised with topical anesthetic at slit-lamp.

EYELID CHANGES

Surgery on the vertical rectus muscles may affect postoperative eyelid position. The effect is the most pronounced when operating on the inferior rectus muscle because of its direct attachment to the lower eyelid retractors. The superior rectus has much looser attachments to the levator palpebrae superioris and the two muscles function independently for the most part. Some change in eyelid position has been reported in up to 94% of inferior rectus recessions and 100% of inferior rectus resections.[78] Most often the change is a few tenths of a millimeter and not clinically significant. Surgery on the superior rectus usually has less noticeable effects on the upper eyelid position.

Prevention of postoperative lid changes includes extensive dissection of the attachments between the rectus muscles and lid retractors. The dissection should be carried back to the level of the vortex veins. This method reduces the pull of the rectus muscle on the lids but does not eliminate it. Some surgeons describe suturing the capsulopalpebral insertion back to the inferior rectus muscle or the sclera in a permanent or adjustable manner.[78,79] Others have described a transconjunctival infratarsal lower eyelid retractor lysis done at the same time as the inferior rectus recession.[80] Many times a second procedure is necessary to address lower or upper eyelid retraction if it is significant. This could include eyelid retractor recessions or spacers with or without lateral tarsal shortening.

Ptosis after strabismus surgery can be due to eyelid edema or even injury to the nerve supplying the levator muscle. This is seen in surgery of the superior oblique or the superior rectus. If there is excessive traction on the levator or a hook passed too far posteriorly along the superior rectus, direct damage can occur to the levator muscle or its nerve. The nerve to the levator traverses the superior rectus 26 mm posterior to limbus.

DELLEN

Dellen are depressions in the ocular surface due to inadequate lubrication and inadequate lid coverage of the peripheral cornea. This is the result of elevation of adjacent edematous conjunctiva. If severe enough, this can result in loss of corneal epithelium and can lead to pain. As the conjunctival edema subsides and the corneal surface heals, scarring can develop. Dellen are most commonly seen after rectus muscle resections. The resected muscle pulls more tissue anteriorly and creates more perilimbal elevation. The incidence of dellen in one large study was 15% of resections with a limbal conjunctival incision and 5% of resections with fornix conjunctival incisions.[81] There was only one case of dellen in 199 recessions. The incidence of dellen can

Focus Point #5

The blood flow to the anterior segment of the eye passes via the rectus muscles. Anterior segment ischemia can result by interrupting this flow after extraocular muscles are detached.

be reduced if less tissue is pulled forward in an adequately cleaned muscle. It is important to avoid corneal limbal override by suturing the conjunctiva to the limbus or trimming excess tissue. The use of ice and head elevation for the first 24–48 hours after surgery can help reduce conjunctival swelling significantly. Once dellen form, adequate lubrication with ointment and patching the eye can be helpful.

HEMORRHAGE

Significant hemorrhage is rare in strabismus surgery. The space underlying Tenon's capsule is relatively bloodless. Bleeding is more often encountered after cutting extraocular muscle tissue or the anterior ciliary vessels associated with the rectus muscles. Judicious use of bipolar cautery can be safely used to control bleeding. On occasion, removing the lid speculum and holding direct pressure over the eye will control bleeding from areas hard to control with cautery. Care should be taken to avoid lacerating or avulsing the vortex veins. The vortex vein can bleed significantly and is difficult to control with cautery and direct pressure. The surgeon should carefully ensure that all active bleeding vessels are controlled before the end of the case. Postoperatively one should expect pink, blood-tinged tears as part of the normal course of recovery in the first 24–48 hours. Active bleeding should be treated with direct pressure or patching if the source is anterior and visible.

Orbital or retrobulbar hemorrhage has been reported as late as 36 hours after surgery.[82] A large hemorrhage is most likely associated with a bleeding anterior ciliary vessel. Orbital hemorrhage would present with pain, proptosis, and poor motility. Associated decreased vision could necessitate an emergency orbital decompression with a lateral canthotomy and cantholysis. In such an event, one should consider exploration of the surgical site in order to ensure proper hemostasis.

Focus Point #6

Astigmatism can be induced with horizontal rectus muscle surgery.

SCARRING AND ADHESIONS

Surgery on the lateral rectus muscle can frequently lead to scarring and incorporation of the inferior oblique muscle. There is an intermuscular membrane that extends from the inferior aspect of the lateral rectus muscle to the insertion of the inferior oblique. If care is not taken to cut these connections, the inferior oblique insertion can be drawn up into the lateral rectus. This has been found in up to one-third of cases that required lateral rectus reoperation for other causes.[83] It can manifest as a limitation of elevation in adduction. Avoiding deep dipping when hooking the lateral rectus and careful dissection of the intermuscular septum will avoid this complication.

Severe postoperative restriction of motility may be the result of fat adhesion. This occurs when the Tenon's capsule is violated and tissue scars to the globe and extraocular muscles. It is more common in the setting of multiple operations or trauma.[84] It has also been described in patients after retinal surgery.[85] If fat is encountered, care should be taken to attempt closure of the rent in Tenon's capsule with an absorbable suture. At the end of the case, some surgeons leave a bolus of steroid in the sub-Tenon's space to reduce the risk of scarring. Recent studies investigating the use of mitomycin C and 5-fluorouracil show promise in reducing scarring and adhesions in complicated cases.[86, 87] Sodium hyaluronate and amniotic membrane grafts have also been used to reduce scarring around operated muscles.[88, 89]

REFRACTIVE CHANGES

Several retrospective series describe changes in astigmatism power after strabismus surgery.[90-93] A prospective series found a persistent with-the-rule astigmatism induced by horizontal rectus muscle surgery.[94] Vertical rectus surgery did not induce any refractive change. Astigmatism is increased regardless if one horizontal rectus muscle is recessed, both are recessed, or a resect/recess procedure is preformed.[95] The mechanism for the change in astigmatism is not entirely clear but is most likely due to the change in tension transmitted to the cornea via the sclera. The strabismus surgeon should be aware of the potential for astigmatism change and schedule a cycloplegic refraction in the months following surgery.

PERSISTENT DIPLOPIA

Diplopia after strabismus surgery can occur in the setting of unsatisfactory undercorrection or overcorrection. Forty-seven percent of all patients undergoing strabismus surgery will have diplopia at some point in their postoperative course but only 2% will have persistent diplopia.[96] Of those with excellent postoperative alignment, 10% will have temporary diplopia and only 0.8% will have permanent diplopia.[97] Most will experience a resolution of the diplopia within 2 days to 6 weeks after surgery. A preoperative prism trial can be used to identify patients who could be at risk for postoperative diplopia.[97] If the patient has preoperative diplopia with prisms, he or she is more likely to have diplopia after surgey despite good postoperative alignment. Patients should be aware of this fact and should have the opportunity to forgo surgery if the diplopia would be intolerable. Persistent diplopia after surgery can be a difficult problem, but fortunately it is uncommon. Various techniques

can been used to alleviate the diplopia, including prisms, further surgery, or monocular blurring.

DISCOMFORT AND PAIN

Strabismus surgery is accompanied by minor irritation and discomfort due to swelling of the periorbital tissues and suture ends. Over-the-counter analgesic medications and cool compresses are usually sufficient. Most children are back to their normal activities within 1–2 days of surgery. More extensive surgery or an inadvertent corneal abrasion might prompt the use of narcotics.

Increasing discomfort or severe pain would be unusual and possibly a sign of endophthalmitis and should be investigated promptly.[44,73] Some surgeons use postoperative topical or subconjunctival anesthetics to aid in short-term pain control.[98,99] Intravenous ketorolac intraoperatively can aid in pain control in the immediate postoperative period and appears to be more effective than oral acetaminophen or ibuprofen.[100]

Conclusion

Strabismus surgery, like any surgery, has complications. Fortunately, the most serious complications are quite rare. Care must be taken, however, to understand how and why things can go wrong in strabismus surgery. Many potential problems can be avoided by taking the proper steps. When a complication does arise, it is important to understand the potential treatments and when they should be instituted.

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