



Damage Control Ophthalmology

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Introduction

The concept of damage control surgery was developed by trauma surgeons as a methodology to focus the initial trauma surgery effort, after significant injury, toward dealing with the trauma triad of death: coagulopathy, acidosis, and hypothermia. Thus, their initial surgical effort emphasizes physiologic recovery over anatomic reconstruction [1]. As ophthalmologists performing surgery in times of conflict on one of the most important sense organs, that of sight, with triage imperatives of protecting life, limb, and eyesight, we may be required to operate alongside and sometimes simultaneously with our trauma surgeons during this damage control period. Given that >70% of ruptured globes during our most recent military conflicts were associated with significant systemic injuries, we have by necessity and doctrine been performing our own version of damage control surgery for decades [2].

Due to the unique physiology and anatomy of eye structures, our approach to damage control

ophthalmic surgery is by necessity very different from our trauma colleagues who delay anatomic reconstruction in an effort to restore physiologic function [1]. Like our trauma colleagues, our approach involves careful surgical planning with repair of critical anatomic structures in a staged approach, which if adhered to results in optimum outcomes for the patients.

Critical to this process is an understanding of the anatomic and physiologic processes of the eye. Repair of a seriously injured eye should not be undertaken unless the physician understands the anatomy, physiologic, and pathophysiology of trauma; can properly classify the injury; and knows the unique features of each injury type [3]. Additionally, to optimize outcomes, the damage control ophthalmology principles should be implemented within the framework of a larger trauma designed to protect the eye from point of injury, through the chain of evacuation, to the ophthalmic surgeon. In this chapter, we cover the basic framework of damage control surgery. The following chapters discuss aspects of the surgery in greater detail.

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Terminology

To understand the principles of damage control ophthalmology and to define the prioritization of effort, we need a common nomenclature to describe injuries to the eye. The University of

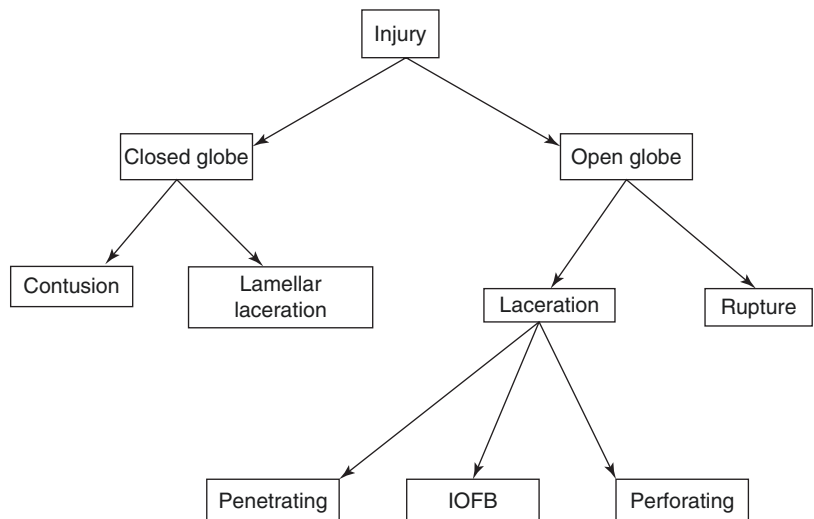
Alabama Birmingham developed a nomenclature that has been accepted by the American Academy of Ophthalmology and the International Ocular Trauma Society [4]. Central to the nomenclature is the concept that all definitions refer to the entire globe and not individual tissues. If a tissue is mentioned, it is done so to

qualify the location of the injury. Table 2.1 outlines the agreed-upon terminology for ocular injuries. Figure 2.1, from the Birmingham original publication, shows graphically how this terminology is employed. Figure 2.2 utilizes a decision tree to assist the provider in determining the correct terminology.

Table 2.1 Table of terminology [3]

Term	Definition	Comment
Eye wall	Sclera and cornea	Though the eye wall has three layers posterior to the limbus, clinical and practical purposes dictate that violation of only the most external tissue (sclera) is to be considered
Closed globe injury	No full-thickness wound of eye wall	The cornea and the sclera are not breached through and through
Open globe injury	Full-thickness wound of the eye wall	The cornea and/or sclera is breached through and through
Contusion	No wound of the eye wall	The damage may be due to the direct energy delivery/shock wave by the object (i.e., choroidal rupture), or to changes in the shape of the globe (i.e., angle recession)
Lamellar laceration	Partial-thickness wound of the eye wall	The wound in the eye wall is not “through” but “into”
Rupture	Full-thickness wound of the eye wall, caused by a large blunt object	Since the eye is filled with incompressible liquid, the impact results in instant <i>intraocular pressure</i> (IOP) elevation. The eye wall yields at its weakest point (rarely at the impact site, rather, for instance, along an old cataract wound); the actual wound is produced by an inside-out mechanism, and tissue prolapse is almost unavoidable
Laceration	Full-thickness wound of the eye wall, caused by a sharp object	The wound is at the impact site and is created by an outside-in mechanism; since <i>intraocular pressure</i> (IOP) elevation is unavoidable, tissue prolapse is common
Penetrating injury	An entrance wound is present	If more than one wound is present, each must have been caused by a different object
Intraocular foreign body (IOFB)	One or more foreign objects are present	Technically a penetrating injury, but grouped separately because of different clinical implications (management, prognosis)
Perforating injury	Both an entrance and an exit wound are present	The two wounds caused by the same agent

Fig. 2.1 Graphic representation of employment of the terminology of eye injuries [4]



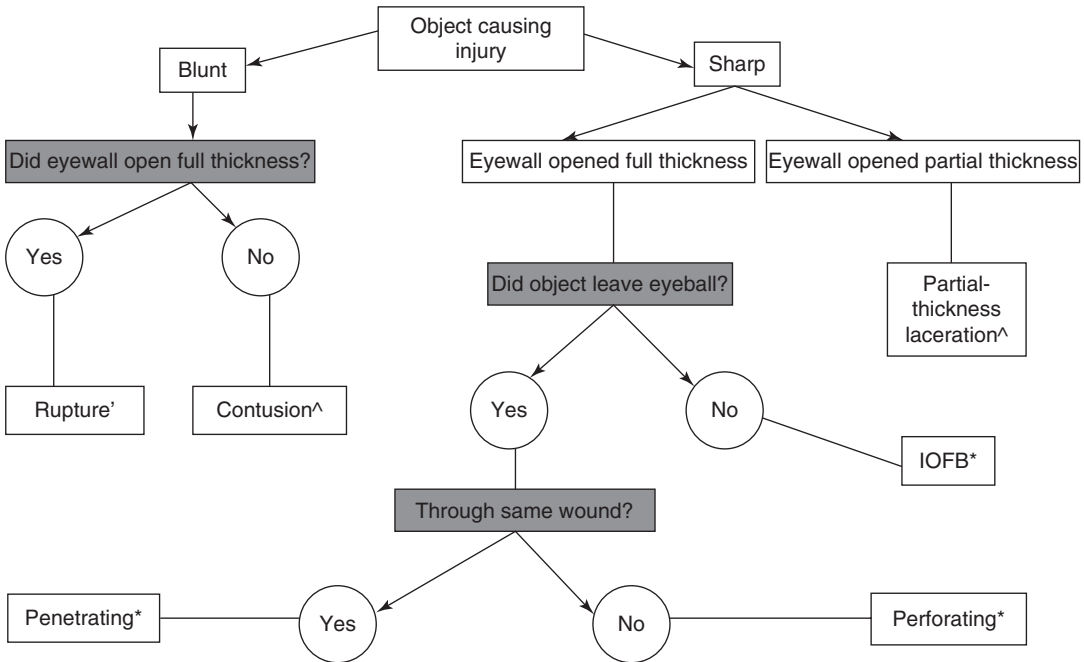


Fig. 2.2 Decision tree to assist the provider in determining the correct terminology. Injuries marked with asterisk (*) are open globe injuries. Injuries marked with caret (^) are closed globe injuries [4]

Ocular Trauma Score (OTS) has been devised to assist in communicating with patients regarding the likelihood of visual recovery after surgery.

Ocular Trauma Score [5]

Through the evaluation of 2500 trauma patients, the Ocular Trauma Score was developed to reliably predict the functional outcome of serious eye injuries. The Ocular Trauma Score is easy to calculate: The patient is given initial points for their initial vision. Then points are deducted for the presence of a globe rupture, endophthalmitis, perforating globe injury, retinal detachment, or afferent pupillary defect, according to a standardized value for each (Table 2.2).

The final raw points are then converted into an OTS, and Table 2.3 gives the likelihood of the final visual acuity separated into five categories.

By employing the information given by the OTS, we can now counsel our patients and more

Table 2.2 Calculating the Ocular Trauma Score (OTS): variables and raw points [5]

Variable	Raw points
Initial vision	
NLP	60
LP/HM	70
1/200–19/200	80
20/200–20/50	90
≥20/40	100
Rupture	–23
Endophthalmitis	–17
Perforating injury	–14
Retinal detachment	–11
Afferent papillary defect	–10

predictably engage them in the triage, management, and rehabilitative process they can expect as a result of their injury.

Triaging Eye Injuries

Critical to the proper employment of damage control ophthalmic principles, the process of triaging injuries is paramount. There is no delayed primary closure of open globes. Open globes

Table 2.3 Calculating the OTS: conversion of raw points into an OTS category, and calculating the likelihood of the final visual acuity in five categories [5]

Sum of raw points	OTS	No light perception (%)	Light perception/hand motion (%)	1/200–19/200 (%)	20/200–20/50 (%)	≥20/40 (%)
0–44	1	74	15	7	3	1
45–65	2	27	26	18	15	15
66–80	3	2	11	16	31	41
81–91	4	1	2	3	22	73
92–100	5	0	1	1	5	94

should be closed as quickly as possible in an effort to prevent choroidal bleeding, infection, and epithelial downgrowth.

The open globe is always at risk for expulsive hemorrhage, in which bleeding from underneath the retina forcefully pushes all the intraocular structures out of the eye, causing total blindness. The normal intraocular environment is an intraocular pressure (IOP) of 15–20 mm Hg above atmospheric pressure. When the eye is open, the pressure drops to 0 mm Hg. The retinal and choroidal vasculature are anteriorly displaced placing traction of the vascular plexus where they are tethered at the intrascleral canals [6]. Additionally, the low intraocular pressure exacerbates the transmural forces across the vascular structures, shifting the Starling forces toward accumulation of fluid in the extravascular space (choroidal effusion) [6]. These forces are exacerbated if the patient suffered from pre-injury elevated intraocular pressure or elevated episcleral venous pressure such as would occur with glaucoma. If the injured patient was older, suffered from atherosclerotic vascular disease, heart disease, hypertension, obesity, or diabetes (all of which can increase the fragility of their vascular system), their risk of intraocular bleeding is elevated. This risk slowly increases the longer the eye is opened.

In the absence of a direct wound or intraocular foreign body, the risk of infection does not measurably rise if the globe is closed within 24 hours [7]. The only exception is when the globe cannot be successfully closed or has endured so much damage that sight is not possible. In those cases, enucleation or evisceration should be entertained. If enucleation is to be performed, every effort should be made to include the patient in the conversation.

As is evident by the ocular trauma score, visual acuity is very important in triaging eye injuries. In general, the worse the presenting visual acuity, the worse the final visual outcome.

General Principles of Damage Control Ophthalmic Surgery

Open globes should be closed as quickly as possible in a water-tight fashion (to prevent expulsive hemorrhage, infection, or epithelial downgrowth). There is no delayed primary closure. After closure is performed, verification of water-tight status is performed via the Siedel test.

- When confronted with a complicated multiple-wound globe trauma, it can be challenging to know where to begin. All patients undergoing repair therefore should be under general anesthesia to allow for full and careful exploration of the extent of their injuries without causing any additional trauma to the intra and extra-ocular structures.
- Any foreign bodies protruding through the lids, cornea, or conjunctiva should be stabilized and not removed until it can be fully investigated.
- Always work from the known to the unknown. To do this, you need to ensure you have adequate exposure by carefully retracting the eyelids using specialized lid retractors that are developed to take pressure off the globe such as the Jaffe or Schott lid speculums. If those are unavailable or the injury to the lids is not amenable to accommodating the proper speculums, you may consider using a temporary

stay suture in the upper and lower tarsus to retract the lids up and away from the globe.

- Once the eye is adequately exposed, carefully begin identifying structures that are easily recognizable such as areas of the limbus. Generally, it is best to work anterior to posterior so that intraocular contents will not be inadvertently expressed while trying to reach more posterior wounds.
- If possible, administer broad-spectrum intravenous (IV) antibiotics as close to time of injury as possible.
- The globe should be closed before ocular manipulations are performed (such as forced ductions).
- If there is a full-thickness lid laceration present, one should rule out the presence of an open globe beneath.
- Use nylon sutures, especially if future reconstructive surgery is anticipated in the immediate future.
- A 360-degree peritomy should be performed starting from the unaffected side slowly working your way to the involved area of the globe, being careful not to exert any undue pressure on the globe.
- Close limbus first with 9-0 nylon surgery, close cornea next with 10-0 nylon sutures, then close the sclera with 8-0 nylon suture. Close as far back as can be performed without causing undue pressure on the globe.
- In general, do not excise cornea tissue, ciliary body, choroid, or retina (unless grossly contaminated).
- After all visible and easily accessible wounds have been closed, all four quadrants should be explored, taking care to isolate all four rectus muscles and search underneath and posterior to their insertions to ensure there are no other hidden injuries.
- One to two rectus muscles can be disinserted from the globe using standard strabismus surgery techniques to ensure the muscle will not be lost and can be easily reinserted. Disinsertion may allow for better visibility and exposure of more posterior wounds.
- Very posterior wounds that cannot be safely reached should be left to close on their own (they typically fibrose and close within 1 week).
- Simple interrupted sutures are preferred. Complicated lacerations may require mattress or running sutures.
- Iris and retinal tissue should be repositioned unless it is contaminated, necrotic, or has been out of the eye for >24 hours.
- Vitreous outside the wound should be excised via Wexcell or vitrector (vitrector is preferred); care should be taken to not pull on the vitreous as it can exacerbate intraocular injuries.
- Hyphema should be evacuated in the acute setting. It should be performed only if the IOP cannot be controlled or there is evidence of corneal blood staining.
- Lens injuries do not necessarily have to be addressed immediately (early removal can facilitate visualization of the posterior segment).
- Intraocular lens implantation should be delayed until there are no signs of infection or posterior segment pathology.
- Due to the risk of sympathetic ophthalmia, all open globes should be closed. If it is not possible, then it should be excised within 2 weeks with complete removal of all uveal tissue.
- If there are adnexal injuries around the eye, always check for canalicular laceration; these should be stented with a suitable stent as soon as possible.
- Confirmed intraocular foreign bodies should be removed immediately (possible exceptions—non-vegetative, non-toxic intraocular foreign bodies (IOFBs) from blast injuries can undergo delayed removal).
- Non-sutured posterior perforating injuries take 1 week to scar and stabilize and will not receive immediate surgery. (This should be taken into consideration when arranging aero-evacuation in potentially high-risk environments.)
- Many small intraorbital foreign bodies can remain in the orbit without much consequence. Therefore, if a foreign body is not easily accessible or amenable to safe removal at the time of the initial closure, it may remain in the orbit to be dealt with at a later time if necessary.

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