

# Fluoroscopy: Radiation Protection of the Eye



©2010 ASRT. All rights reserved.

# Fluoroscopy: Radiation Protection of the Eye

Bryant Furlow, BA

*Visual system tissues, particularly the lens of the eye, are extremely vulnerable to the harmful effects of ionizing radiation. There is no well-established “safe” level of radiation exposure for the eyes. With the expanding use of fluoroscopy and fluoroscopy-guided interventional procedures, radiation doses to patients have increased dramatically. Radiation dose management is crucial to protect the eyes of patients and health care personnel who perform fluoroscopic exams.*

*Dosimetric monitoring and dose minimization practices — including planning, careful selection of fluoroscopy imaging modes, the proper use of protective equipment and shielding, effective quality assurance and quality control programs, and adequate operator training — all play important roles in protecting the eyes of patients and health care personnel.*

## After completing this article, readers should be able to:

- Describe the functional anatomy of the eye.
- Explain how ionizing radiation can disrupt the structure, physiology and function of visual system tissues.
- Discuss different types of visual system diseases and disorders and their relation to ionizing radiation exposure.
- Discuss changing views about dose thresholds for radiation cataract formation.
- Identify how staff position with regard to the fluoroscopy unit and patient can affect dose.
- Describe strategies for minimizing patient and staff radiation doses during fluoroscopic procedures.
- Explain why fluoroscopic radiation dose to the eye lens is a major occupational exposure concern and how the threat of chronic exposure can be mitigated.
- Describe sentinel event thresholds requiring postfluoroscopic monitoring for radiation injury.

**F**luoroscopy and other imaging modalities have revolutionized modern medicine, providing physicians with invaluable anatomical and physiological information about their patients. The range of fluoroscopic examinations, particularly fluoroscopy-guided interventional procedures, has proliferated over the past 20 years. Because of prolonged examination times and other factors, patient radiation doses and the incidence of serious radiation injury from fluoroscopy also have increased.<sup>1</sup> For example, interventional fluoroscopy for transcatheter embolization involves patient radiation doses of up to 100 mSv, an amount that is 1,000 times the dose delivered by a typical chest radiograph.<sup>2</sup>

Visual system tissues, particularly the lenses, are very vulnerable to damage caused by ionizing radiation and, therefore,

are of particular concern to patients and health care personnel. Fluoroscopy not only can expose the eyes of patients to varying doses of ionizing radiation, but also the eyes of surgeons, radiologists, radiologist assistants (RAs), radiologic technologists and other personnel who are involved in these procedures. Fluoroscopic radiation doses are subject to the type of examination, target tissue, exam duration, and the radiation protection practices and specific equipment used.<sup>1</sup>

Ionizing radiation is not the only potential medical imaging hazard to the visual system. In fact, animal experiments suggest that ultrasound energy can cause free radical damage to the endothelial cells of the cornea.<sup>3</sup> However, ionizing radiation is a well-established threat to visual system integrity and health, and the higher radiation doses associated with

fluoroscopy must be considered when planning and performing procedures.

This article describes the anatomy and physiology of the eye, the biological effects of ionizing radiation on the eye and the implications of radiation pathobiology for radiation protection of the eyes. The article also discusses the risks posed by long-term exposure to low-dose scatter radiation to the eyes of health care professionals.

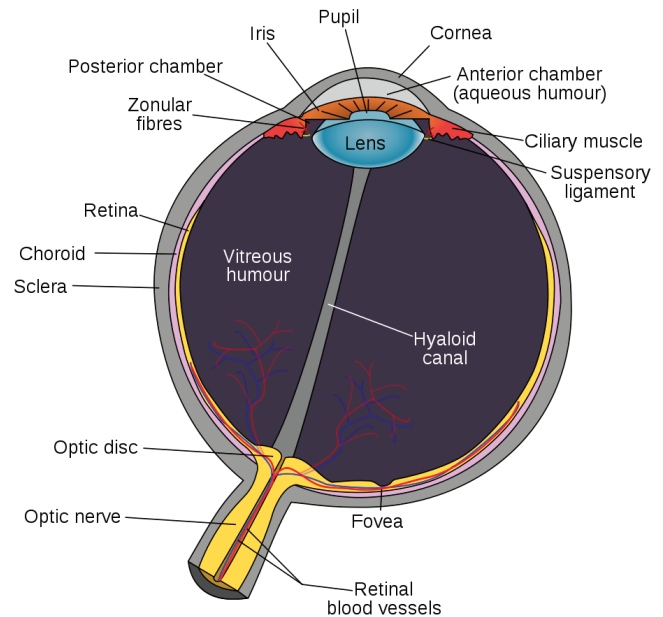
## History

Ophthalmology evolved over the centuries from folk cures and quackery to a systematic, scientific field of medicine and surgery. The first published description of eye anatomy, Benvenuto Grassi's *De Oculis*, appeared in 1474, at which time ophthalmology was a primitive medical endeavor. Eye medicine was the dubious province of barbers, who also practiced crude dentistry and general surgery.<sup>4</sup> Physician Leonhart Fuch's 1539 text *Alle Kranckheyt der Augen* (*All Illnesses of the Eyes*) was an early scientific text on ophthalmology; it systematically described the eye's anatomy, pathologies and treatments.<sup>4</sup>

Surgeon Jacques Daviel explained the surgical removal of cataracts in 1753, and by 1817 a 2-volume ophthalmology textbook was published, marking the early origins of ophthalmology as a distinct field of medicine.<sup>4</sup> In 1820, partly in response to an epidemic of trachoma bacterial infections of the eye, Benjamin Travers wrote the first English-language ophthalmology text, *A Synopsis of the Diseases of the Eye*. By 1900 ophthalmology was a well-established medical field.

## Functional Anatomy of the Eye

The human eye is frequently described as the "window to the soul" or, less poetically, compared with a simple camera with respect to its ability to capture images. Simply put, light enters the eye through a refracting cornea; the cornea redirects light to the retina, where photon energy is converted into an electrochemical signal that is transmitted to the brain. The components of the eye reduce light scatter, improve focus and control the aperture through which light enters the overall structure. In reality, the eye is a much more complex and dynamic structure than George Eastman's Kodak machine or even, arguably, contemporary magnetic resonance (MR) and computed tomography (CT) scanners.



**Fig. 1.** Gross anatomy of the eye. (Used with permission from Wiki Commons, <http://commons.wikimedia.org>).

We understand the gross anatomy and overall function of the eye reasonably well (see Figure 1); however, we know little about the biology, genetics and pathobiologies of the eye's protein structures and immunological defenses. The molecular biology of ocular surfaces, cell membranes and mucosal secretions, not to mention the intricate neurobiology of the visual pathway, also are not well known.<sup>5-8</sup>

In the most general terms, the eye consists of 3 primary tissue layers. The protective outer layer of the eyeball, or globe, is the tunica fibrosa, a tissue rich in collagen and elastins.<sup>9</sup> The tunica vasculosa, more commonly referred to as the uvea (from the Latin *uva*, or grape), is the middle layer of the eye orb. As the term "vasculosa" suggests, this layer contains the eye's vasculature, as well as its pigmented iris.<sup>9</sup> The innermost primary layer of the eye is the tunica nervosa, named for the optic nerve and the fact that it originates as an outgrowth of the developing fetal brain.

Early in prenatal development, the embryo's anterior neuroectodermal tissue layer folds into the optic cup and eventually the eyeball. Neuroectodermal tissue also forms the neural crest and tube, an early developmental phase of the central nervous system.<sup>9</sup> The tunica fibrosa