Overview of Ophthalmic Equipment and Support Systems for Ophthalmology

Health Care Technology Unit
ORBIS DC-10 Flying Eye Hospital
Introduction

• Eye anatomy and common diseases
• Diagnostic instruments
• Therapeutic instruments
• Additional ophthalmic instruments
• Support systems for Ophthalmology
Anatomy of the Eye

- Lens
- Cornea
- Iris
- Aqueous Humor
- Sclera
- Macula
- Choroid
- Retina
- Optic Nerve
- Vitreous Humor
Key anatomy of

• **Cornea**: protective outer layer, triggers blink reflex, tear duct secretion, and 2/3 of total refraction.

• **Aqueous Humor**: clear fluid behind the cornea.

• **Iris** (pupil) constricts and dilates

• **Retina**: coats the back of the eye, image sensor

• **Lens**: flexible, transparent, provides 1/3 refraction that focuses an image on the retina.

• **Vitreous Humor**: semi-gelatinous material filling the volume between the lens and the retina.
Six sub-specialties of ophthalmology

1. Cornea & Cataract
   - Cataract
   - Corneal Diseases

2. Retina & Vitreous
   - Retinal Detachment
   - Macular Diseases
   - Diabetic Retinopathy
Six sub-specialties of ophthalmology

3. Glaucoma

4. Oculoplastics (trauma, birth defects, tumors, cosmetics)

5. Pediatrics & Strabismus

6. Neuro-ophthalmology (optic disk, optic nerve, brain)
Optical tools to view the eye

Direct Ophthalmoscope

Doctor

Patient
Optical tools to view the eye

- View provided by the direct ophthalmoscope:
  - monocular;
  - non-stereoscopic (2D);
  - narrow field (5°);
  - magnified about 15X.
Optical tools to view the eye

Binocular Indirect Ophthalmoscope (BIO)
Optical tools to view the eye

Binocular Indirect Ophthalmoscope (BIO)

Doctor

Patient

Hand held Lens

~60mm

~15mm
Optical tools to view the eye

**Binocular Indirect Ophthalmoscope (BIO)**

- Instrument of choice for retinal examinations.
- Used in conjunction with a condensing aspheric lens held close to the patient’s eye.
- BIO provides:
  - a much wider field of view (45°) than a direct ophthalmoscope;
  - permits viewing of almost all the patient’s retina;
  - stereoscopic view (3D);
  - inverted;
  - illuminated with magnification of about 5X.
- Some BIOs have a built-in video camera to permit eye care professionals in-training to view the examination on a video monitor.
Optical tools to view the eye

**Slit Lamp**

Used to view the external and internal structures of the eye under magnification and illumination
Optical tools to view the eye

Slit Lamp
Optical tools to view the eye

Fundus camera, retinal camera
Optical tools to view the eye

**Fundus camera, retinal camera**

- Specialized low power microscope with an attached camera, designed for taking pictures of the back of the eye, or fundus.
- Often used in fluorescein angiography:
  - fluorescein dye is injected into a patient to reveal retinal circulation.
- Digital fundus cameras can be interfaced with a computer for storage of the retinal images as graphic files:
  - files can be archived, edited, printed or sent to other eye care specialists through a local area network or over the World Wide Web.
Optical tools to view the eye

Fundus camera, retinal camera
Diagnostic tools for quantitative measurements

**Tonometer**

- Applanation: Measures the force that is required to flatten the cornea in mmHg.
- Non-contact: A soft puff of air is directed to the patient’s eye and the resulting corneal deformity is measured and converted to pressure.
- Schiotz: A footplate that is placed on the cornea and a central movable plunger that is fitted into a barrel. Attached to the plunger is a needle and scale for measurement.
Diagnostic tools for quantitative measurements

Keratometer

• Measures the curvature of the anterior central zone of the cornea (K readings, in millimeters radius of curvature or in diopters);

• K readings are used for fitting contact lenses, evaluating corneal astigmatism and for calculating intraocular lens (IOL) power.
Diagnostic tools for quantitative measurements

Phoropter, refractor

- Can reproduce virtually any possible optical correction.
- Measures the curvature of the anterior central zone of the cornea (K readings, in millimeters radius of curvature or in diopters);
- K readings are used for fitting contact lenses, evaluating corneal astigmatism and for calculating intraocular lens (IOL) power.
Ultrasound can provide quantitative and qualitative information about the eye

A-scan

- Ultrasonic waves are reflected at interfaces
- A-scans give accurate quantitative measurements
A MODE

A·SCAN

ORBIS
saving sight worldwide
Probe on axis

MACULA

Probe On Axis

Cornea
Anterior Lens
Posterior Lens
Retina
Sclera
Orbital Fat
Ultrasound can provide quantitative and qualitative information about the eye

**B-scan**

- B-scans have a moving transducer which scans in 2 dimensions
- B-scans provide a qualitative view of the eye
Example: Retinal detachment
THE ULTRASONIC EXAMINATION OF THE EYE

• Topographic analysis: B mode (Brightness)

• Quantitative analysis: A mode (Amplitude) Biometry

• Kinetic analysis: B Mode and/or Doppler
Operating Microscopes allow Microsurgery on Exterior and Interior of the Eye
Operating Microscopes
Operating Microscopes

• Utilized for procedures that require high magnification and variable focusing.
• Light from a halogen light source is directed into the tube through prisms or fiber optic cables and shines through the objective lens onto the operating field.
• Magnification of the eyepieces is typically 8X to 20X.
• The typical focal length (working distance) of objective lenses for eye surgery using a 12.5X eyepiece is 175 to 200 mm
Phacoemulsification

- Ultrasonic energy (25 - 80Khz), is used to break up the opaque lens into smaller pieces that are then aspirated out of the eye.
- After the entire cataract is removed, an intraocular lens (IOL) is inserted in place of the eye’s lens.
Phacoemulsification
Vitrectomy
Vitrectomy

Anterior Vitrectomy

Posterior Vitrectomy
Vitrectomy
Cryo Surgical Units - CSU
Cryo Surgical Units - CSU

- CSU apply a refrigerant (cryogen) to withdraw heat from target tissue through contact with a cryogen-cooled probe.
- The effect is to freeze the surrounding tissue so that it dies.
- In the tissue immediately beyond the killed zone a degree of coagulation occurs thus limiting the resulting bleeding.
- Different types of interchangeable cryo probes are available for different applications.
- Cryogens in ophthalmology: Compressed nitrous oxide (N2O) and carbon dioxide (CO2).
Ophthalmmic LASERs
Laser are used as therapeutic ophthalmic equipment

- Different laser have different properties and are used for different therapies

- **Argon**
  - 488, 515 nm
  - blue/green

- **Nd:YAG**
  - 1064 nm
  - infrared

- **Diode**
  - 810 nm
  - infrared

- **Excimer**
  - 193 nm
  - ultraviolet
Lasers allow non-invasive surgery

Glaucoma

Argon

Argon, Nd:YAG

Cataract

Nd:YAG
Lasers allow non-invasive surgery

Retinal diseases
Argon
Or
Diode

Refractive correction
Excimer
Laser Delivery systems

- Slit lamp
- Endoprobe
- Indirect ophthalmoscope
- Operating microscope
Diode Laser with Slit Lamp
Diode Laser with Endoprobe
Diode Laser with Indirect Ophthalmoscope
LASER SAFETY

Warning sign

Protection curtain

Light signal

Door contact

EYEelite

Accessories

Ventilation and air filtering
Bioengineered operating room supplies

**Sutures**
- Biodegradable

**Viscoelastic**
- Methylcellulose

**Intra-ocular lenses**
- Polymethylmethacrylate
- Silicone (foldable)
Support systems for ophthalmology
Machines to anesthetize and monitor the patients

Boyle’s apparatus

vaporizer

flow meter

regulator

gas

ECG

blood pressure

pulse rate

blood O_2

respiration

expired CO_2

temperature
Modern Anesthesia Machines
Continuous-flow anesthesia system

Figure. Continuous-flow anesthesia system

Reproduced from Health Care Product Comparison System, ECRI. 2003 – Anesthesia Units
Surgical equipment must be sterilized

**Autoclave**
- 27 psig
- 132 °C
- 10 min

**Ethylene oxide (EtO)**
- 55 °C
- 3.5 psia
- 1 hr treat
- 15 min vent

**Heat flash**
- 190 °C
- 6 min

**Autoclave/EtO bags**
- Clear, impermeable front
- Semi-permeable backing
Acknowledgements

• ALCON Laboratories