Part 2

The Anticipated Hazards Due to Errors In Using Laser In Medicine & Recommendationms for the Safe Use Of Medical Laser Systems in Iraqi Hospitaals

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• Causes of Laser Hazard

I - Inherent Hazards to Laser Beam

Direct or reflected laser beams have consequential health effects range from minor skin burn to irreversible eye injuries. The hazards depend on the power output and wavelength of the used laser and depend on the exposure time and MPE. ti & 2)

A- Eye Hazards

Point light source cause more damage to eyes than large sources, because point sources concentrate into a very small point on the retina with a high power density. So direct laser beam or specular reflected laser beam cause more damage than diffusely reflected laser beam.

1- UV C (200 nm - 280 nm) & UV B (280 nm - 315 nm) absorbed by the cornea, causing photokeratitis.

2- UV A (315-400 nm) absorbed by the lens, causing cataract.

3- Visible (400 nm - 700 nm) & near IR (700 nm-1400 nm) pass and focus to 100000 time by cornea and lens, and absorbed by retina. The heat causes retinal burn. Also cause photochemical damages.

4- IR B (1400 nm - 3000 nm) & IR C (3000-1000000 nm) absorbed by tears and water of the cornea, causing corneal burn. Also iR B cause cataract.

B- Skin Hazards

1- UV C causes erythemia, accelerate aging and skin cancer 2- UV B causes increase pigmentation.

3- UV A causes increase pigmentation and skin burn.

4- Visible laser causes photosensitivity, increase pigmentation skin burn.

5- IR laser causes skin burn ranging from mild burn to sever ulceration and
scarring.

II- Hazards Associated With Operator Work Procedures

These are due to improper training of LO and lake of familiarity with medical laser systems. " & z) The LSO avoid these hazards by:

1- Provide training to LO

2- Define SOP.

3- Make precaution labels.

III- Hazards Associated With Laser Use: (1&2)

1- Laser generated air contaminations (LGACs)

LGACs are productions of interactions of usually high power laser with target tissue. This causes a plume that may contain infectious virus as AIDS and hepatitis B, or may contain industrial toxic materials as cyanide. LGACs must be removed by continuous suction during laser operation.

2- Chemical hazards, as:

- Laser dyes. The dye powder and its solution are toxic.
- Cryogenic fluids may cause explosion.

3- Electrical hazards.

Medical laser systems are high voltage systems that may cause electric shock due to deficiency in supplies, non-isolation, poor function switches, etc.

4- Collateral (non-laser) radiation, as:

- Ionization radiation. If the power supply is more than 15 KeV, it
produces x-rays, causing carcinoma and genetic hazards in pregnant LO.
- Visible and UV radiation from power pumping part of laser system. It is
dangerous if exceed MPE.
- Plasma emission due interaction between target tissue and ultra-short laser, causing UV hazards.
- Radio frequency hazards in Q-switch laser.

5- Fire hazards.

Solutions used in dye laser are flammable. Also high power laser may cause ignition of dressings, clothes, alcohol, etc.

6- Explosion

Explosion of the laser device due to high-pressure arc or flash lamp power sources. This can be prevented by proper mechanical shielding.

Review of Clinical Studies

Statistics of the results of clinical studies on accidents system showed: (2)

1- **Causes of laser accidents**

The causes of laser accidents are due to:

Errors in alignment procedures (28%)

- High voltage system (17%)
- Incorrect eye wears (17%)
- Ancillary hazards (13%)
- Not using eye protection (9%)
- Equipment malfunction (9%)
- Improper services (4%)
- Accidental exposure (2%)
- Others (1%).

2- **Types of laser accidents**

The types of laser accidents are:

- Eye injuries (70%)
- Skin injuries (1 I%)
- Electrical injuries (7%)
- Malfunction of the system (6%)
- Non-harm exposure to laser (4%)
- Fire (1%)
- Others (I%).

Recommendations and Requirements for the Safe Use of Medical Laser Systems in Iraqi Hospitals. (' 2, 3 & 4)

I- General Laser Safety Recommendations and Requirements 1. Eye protection

The human eye is the most sensitive organ in the body to damage from laser light, because its living tissue exposed to environment and because it is the organ of vision; so light is collected and concentrated on the retina. There are no protective membranes or cell layers to insulate this sensitive organ from excessive light exposure.

Natural eye protection includes:

a. Tearing reflex that helps to wash noxious material and foreign bodies from the surface of the eye.

b. Blinking reflex that required 0.25 sec to occur. It enables the eyelids to limit exposure to intense light. Blinking is also triggered by high temperature. But high power laser can cause irreversible eye damage before protection by blinking reflex. Also blinking is not useful for non-visible laser. So eye protection is required.

c. Aversion reflex that include closure of the eyes and movement of the head away to avoid exposure to noxious bright light.

Biological effects of laser beam depend on: 1. wavelength of laser

2. Power and power density of laser. 3. Exposure duration to laser.

The proper selection and use of protective eyewear (goggles and filters) for all class IIIB & IV laser users is a must. This eyewear is design for a specific wavelength and optical density. Also the eyewear should be properly fit and comfortable. Eyewear should not be used interchangeable and should be checked periodically.

2. Use the minimal laser power or energy level required for each application.

3. Beam control, to minimize direct eye exposure, that includes:

- Avoid direct eye exposure. Avoid directing beam path to doors, windows and populated areas.
- Avoid eye exposure to the specular reflection. Minimize specular exposure by using special non-polished surgical instrument and dark no polished wall paintings.
- Locate the laser beam path at a level other than the eye level in standing and sitting poison; not locate it in between 1.2-2 m.
- terminate the laser beam at the end of useful path

4. **Labels to give warning signs** for the LO and other medical staff and for patients. These labels should be written in English and Arabic and should be large and colored. The LSO should put these labels in a clear area to be easily noticed.

Labels for class II laser

Caution
Laser radiation
Do not stare into beam
Class II laser product

احذر
شعاع ليزر من الصنف الثاني
لاتنظر بصورة مباشرة الى الشعاع

Labels for class IIIA laser

Caution
Laser radiation
Avoid direct eye exposure
Class IILA laser products

احذر
اشعاع ليزر من الصنف الثالث أ
لاتنظر بصورة مباشرة الى الشعاع

Labels for class IIIB laser

Danger
Laser radiation
Avoid direct exposure to beam
Class IIIB laser products

خطر
اشعاع ليزر من الصنف الثالث ب
لاتعرض جسمك او عينيك بصورة
مباشرة الى الشعاع

Labels for class IV laser

Danger
Laser radiation
Avoid eye or skin exposure to direct or scattered radiation
Class IV laser products

خطر
اشعاع ليزر من الصنف الرابع
لاتعرض جسمك او عينيك بصورة
مباشرة او غير مباشرة الى الشعاع

II- Specific Laser Safety Recommendations and Requirements for class III & IV Lasers

I. SOP prepared by LSO and attached in a clear area in the laser operative theater. 2. Warning devices as light warning on the entrance of the laser theater 3. Protect skin by cloth, which cover normally exposed areas of LO and by towels for non-operative areas of patients.
4. Proper suction of plums and smokes
5. Safety interlocks for the laser systems
6. Emergency exit and entrance to Laser Theater.
7. Medical laser system must have a master switch with key or code, so only authorized persons can use it.
8. Medical laser system must have permanently attached beam stop or attenuator and emission delay.
9. LSO must define the Nominal Hazards Zone (NHZ). It is the area in which the level of direct or reflected or scattered laser radiation exposure exceeds allowable limits. Definition of this area depends on MPE, power output and wavelength of laser. LO should be trained outside the NHZ.
10. LSO must define the laser control area. This area houses class IIIB & IV laser and it contains all safety measures
11. For high power IR laser as C02 laser, fire resistance must be prepared. 12. Proper insulation and circuit breaker to prevent electric hazards. 13. Reflection control by using material with diffuse reflection. 14. Careful alignment of laser system
15. Be careful of invisible IR & UV laser.

III- The Medical Surveillance Programs

A- Base line medical examination before assignment of LO, that include: I . Occupation history and past laser exposure 2. General eye history and family eye history. 3. History of drugs that may cause photosensitivity. 4. General health, especially of eyes and skin. 5. Visual acuity.
6. External ocular examination, including iris and cornea. 7. Ocular fundus examination.

B- Exit medical examination, and also preferable periodic (1-2 years) examination; that includes:
1. External optical examination
2. Ocular fundus examination
3. Visual acuity

C- Examination after accidents includes:
1. History, especially of the accident.
2. Examination, especially of eyes and skin.
3. Comparing the results with the base line examination, and periodic examination.

IV- Laser Pointers

There are two types of laser pointers available: **1- He-Ne laser pointers.**

It makes a bright red spot with a wavelength of 632.8 rim. It is class 11 laser with a power output less than I mW.

2- **Diode laser pointers.**

It is smaller and cheaper than He-Ne laser pointer. But it is more dangerous because it is class IIIA laser with a power output 5 mW and beam diameter less than 7 mm.

It is preferable to use of He-Ne laser, because it is safer. But never direct the laser beam towards any individual or audience. Also specular reflection is dangerous, so avoid directing it on polished walls or screens.

References

1. ***Laser Safety Manual, of the Florida Atlantic University***
2. Notes on Laser Hazards, by Michael Drewsen, April 2002
3. Laser Safety Manual, of the University of Alabama at Birmingham, 1998
4. American National Standards Institute committee for the Safe use of Laser in Medicine (ANSI-Z136.3)