A study of illumination spectra to improve contrast imaging of biological tissues

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Introduction

Operational lighting is an irreplaceable part of any surgical intervention.

Modern surgical light has:
- Uniform light over the entire area of illumination;
- brightness adjustment;
- uniform light;
- central illumination.

However, it has some drawbacks that prevent an accurate assessment of tissue parameters:
- low tissue contrast;
- insufficient color reproduction;
- lack of volumetric vision;
- insufficient depth of illumination;
- the merger of neighboring structures;
- psycho-emotional stress and rapid fatigue of the operating team.

The aim of research

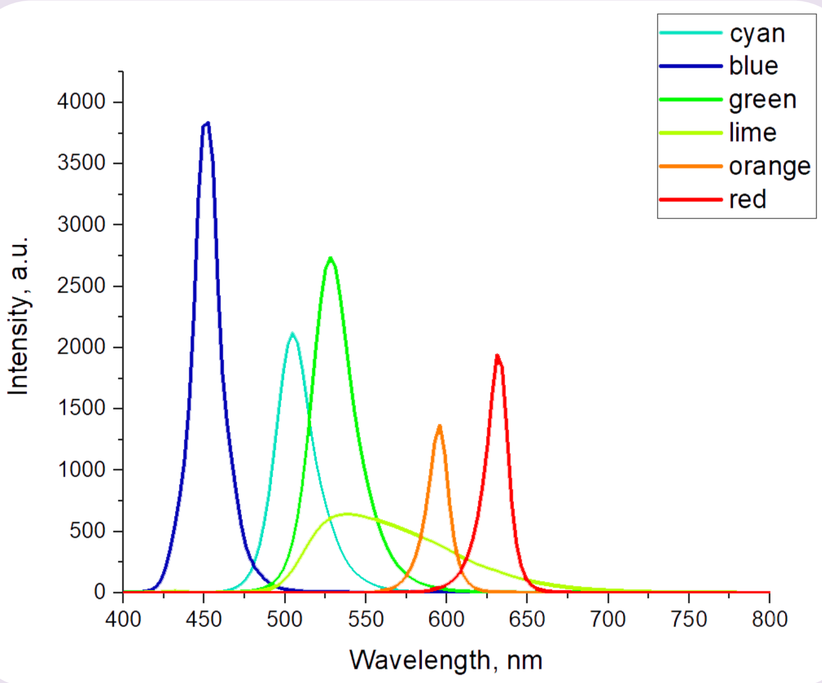
Obtain and study the multicolor semiconductor controlled light source spectral composition of radiation for better visualization of biological structures in the operating field during the surgeon operation.

Materials and Methods

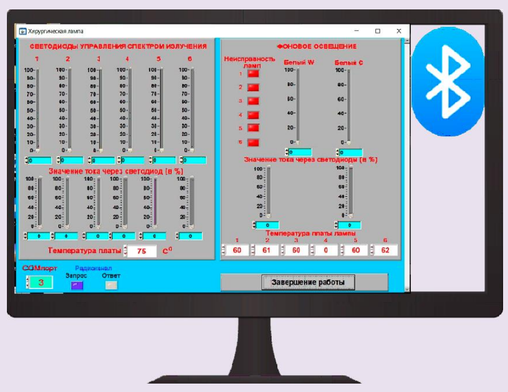
The study was carried out in the following areas of anesthetized male Wistar rats:
- Liver;
- Bladder;
- Nerve fibers;
- Kidneys;
- Spleen.

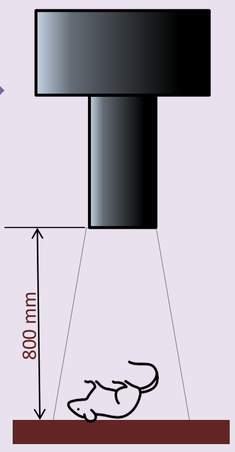
Two independent abdominal surgeons were invited for their feedback and guidance.

1. Interpreting the working principle of the multicolor light source to the surgeon.
2. Setting up the initial lightning regime for the area of interest based on previous work.
3. Dialogue with the surgeon to modify and refine the lighting parameters for an optimal view of the area of interest considered the most appropriate.
4. Registration of the lighting parameters with the MK350 spectrometer.



Emission spectra of matrix chips: blue (450 nm), cyan (504 nm), green (528 nm), lime (533 nm), orange (595 nm) and red (631 nm)

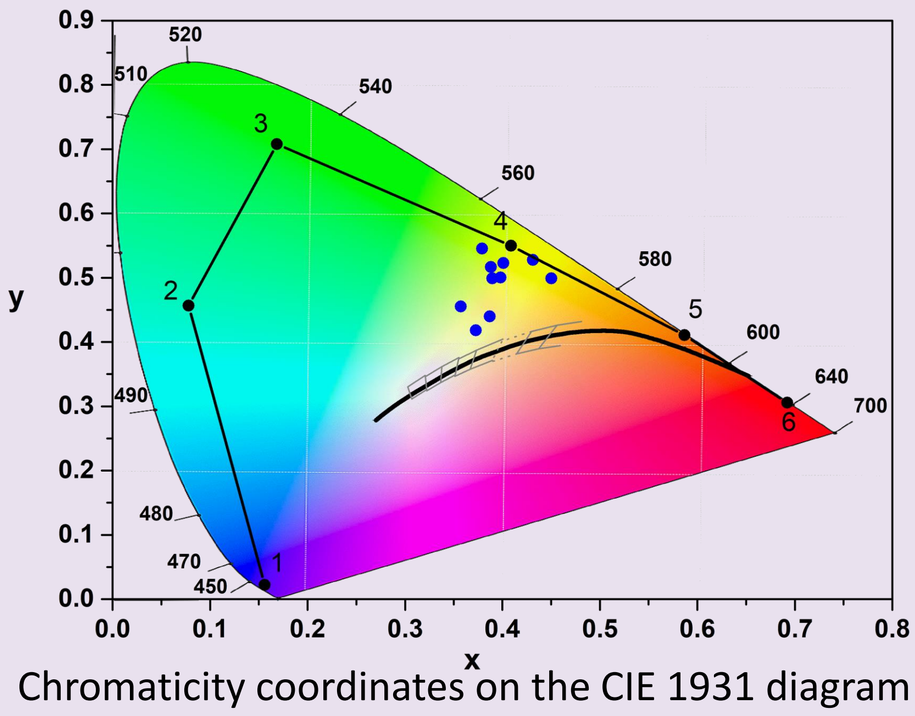




Male Wistar rats

The controlled semiconductor light source was developed by the Microelectronics and Submicron Heterostructures Science and Technology Center of the Russian Academy of Sciences.

Results



Chromaticity coordinates on the CIE 1931 diagram

The surgeons were surveyed for selecting the optimal illumination for a particular area of interest. After choosing the settings in the software, the obtained lighting parameters were measured by a mobile spectrometer at the same distance as the biological object.

After interviewing the surgeons, the lighting parameters were converted into color coordinates in the CIE 1931 color space system and plotted.

The preponderance of the results appear relatively close on the graph. This indicates that with the same initial conditions and gradual iterations, surgeons in most areas of interest arrive at colors that are close to each other. In some cases, the obtained results are very similar, e.g. the selected source modes for the case of nerve fibres against muscle tissue and kidney. For the spleen, however, the results obtained vary considerably.

	Liver		Bladder		Nerve fibers		Kidney		Spleen	
	x	y	x	y	x	y	x	y	x	y
Surgeon 1	0.388	0.517	0.431	0.528	0.357	0.456	0.379	0.5454	0.450	0.499
Surgeon 2	0.373	0.418	0.398	0.500	0.387	0.431	0.401	0.52291	0.390	0.499

Conclusion

- As a result of the work, the initial modes of the light source for better visualization of anatomical structures against the background of biological objects were selected;
- Received results are significantly differ than conventional surgical lightning with CIE1931 coordinate (0.33; 0.33);
- An initial survey of the surgeons was conducted in order to determine the optimal questionnaire to create a common database for the improvement of the multicolor semiconductor light source;
- Similarities and differences in interpretations of optimal light parameters were noted, which demonstrates the necessity of individual selection of lighting during surgeries.