Ensuring the patient's safety during anesthesia is one of the key problems of modern anesthesiology. From the first documented case of death related to anesthesia until the present time, the problem of maximizing safety during anesthesia has been of principal importance in medicine. The selection of the motto "vigilance" at the last World Congress of Anesthesiologists (1988) shows the awareness of the importance of this problem. The American Society of Anesthesiologists (ASA) and similar organizations in other countries in recent years have paid much attention to this issue, since even in the United States during the 1970-80's the annual rate of complications associated with anesthetic care failure was from 2 to 10,000. It should also be emphasized that nearly half of the deaths related to anesthesia could be prevented if adequate monitoring devices were used. Since problems related to lung ventilation are the most frequent cause of anesthesia-related mortality, monitoring devices for assessing ventilation adequacy are in greatest demand.

Safety monitoring is recommended for all patients subjected to anesthesia. This monitoring can be also called protective monitoring against complications. The safety monitoring standards emphasize its specific goal — early diagnosis of complications appearing during anesthesia, to provide enough time for the anesthesiologist to be aware of the problem and to take necessary measures (e.g., connection of the device for artificial lung ventilation to the intubation tube) before irreversible damage to the patient's health occurs. As yet, there is no agreed-upon set of monitoring equipment which ensures the needed increase in patient's safety during anesthesia.

The factors taken into consideration when specifying an optimal standard set of monitoring devices are listed below.

1. Availability of monitoring devices (in 1984 capnographs were not common, and pulse oximeters had just appeared).
2. Cost.
3. Ease of use.
4. Minimal physiological delay of response (alarm signal may be postponed to some extent, but the overall delay should not exceed the physiological period of the changing parameter).
5. Regulated sensitivity (few false negatives).
6. Regulated specificity (few false positives).
7. Predictability (unlikelihood of failure and minimization of incorrect readings).
8. A standard monitor should be reasonably inexpensive. Relatively small expense on safety monitoring can save significant sums of money which are awarded by courts in cases of complications or death related to anesthesia.

Pulse oximeters can presently meet all the listed requirements. They solve a number of problems other types of monitors fail to solve either by incompetence in principle or by having too slow response time.

Pulse oximetry (PO) is a noninvasive method for continuously monitoring peripheral circulation and saturation of arterial blood hemoglobin with oxygen [28, 31]. The method briskly replaces ordinary oximetry and transcutaneous measurement of partial oxygen tension in routine medical practice. According to the literature [26, 33], pulse oximetry will soon be a usual routine monitoring procedure for all types of surgical patients. Pulse oximeters are friendly in use, they do not require calibration or preliminarily warming the patient's skin for proper operation, and they promptly indicate arterial desaturation. Pulse oximetry is presently used (and it is recognized to be necessary) for intra- and postoperative detection of hypoxic hypoxemia [4, 27]. According to the results of a monitoring questionnaire (ZAK, Munich, 1987), PO, together with other methods of monitoring various body functions, is used in 4-18% of patients, depending on the complexity of surgical intervention. By the degree of "usefulness", however, PO is in the lead, and intention of using it grows to 33-48% as compared to other methods of monitoring. According to J. B. Cooper (1988), PO is being increasingly used in medical practice. In 1986, it was used in 21.5% of a studied number of surgical operations (922); in 1987 the corresponding figure was 76.9% (931).

Pulse oximetry enjoys the advantages of two independent methods: spectrophotometry (oximetry) and plethysmography. The operation of pulse oximeters is based on the Lambert—Beer law, which defines the intensity of light transmitted through an object as a function of the incident intensity of light, the object thickness, and the concentration and extinction coefficient of the probed substance in the living tissue. Pulse oximeter continuously monitors light absorption in the infrared (910 nm) and red (660 nm) spectral ranges. Reduced hemoglobin has a higher extinction coefficient in the red spectral region than oxyhemoglobin. Two light emitting diodes are placed at one side of the studied tissue, and a photodetector is placed on the opposite side. No preliminary heating of subjected tissue is required. When passing through the studied tissue, the intensity of light decreases. Arterial blood pulsation changes the volume of the object and results in additional attenuation of light. The overall absorption contains components related to light absorption by venous and by arterial blood in adjacent tissues, and to the additional volume of the arterial pulse wave. (In contrast, the saturation level measured by an ordinary ear oximeter is in fact an average between venous, capillary, and arterial values). It should be noted, that only the last component of total absorption oscillates in time [16, 31]. The oscillations at the two wavelengths are detected, amplified, and displayed as a curve of inverse volume changes. The ratio of the amplitudes recorded at two mentioned wavelengths in apparently healthy patient volunteers under the conditions of an industrial plant was taken as the control level for saturation. For example, if the amplitudes are equal, the level of saturation (HbO2) is approximately 85%. Additional calibration of the device during its subsequent use is not required.

Oximetry as a method of study originated from the works of the German physiologist L. Nicolai, who in 1931 conducted a spectrophotometric study of light transmitted through human skin to elucidate oxygen uptake dynamics in tissues below applied ligatures. His study was continued by K. Kramer, who demonstrated ability of the method in principal to measure true values of saturation. Kramer and his American colleague J. O. Elam knew the Lambert-Beer law to be precisely correct only in solutions of Hb, giving only rough approximation in whole blood, where the relation between the logarithm of intensity of transmitted light and blood saturation depends on the optical path length and on hematocrit. If these two factors are maintained constant, light absorptions in the red and infrared spectral regions are linear functions of saturation. This discovery had a great impact on the future development of oximetry and PO. In 1935, K. Kramer reported the long-term monitoring of blood saturation in intact arteries in animals. At the same time, his compatriot K. Matthes from Leipzig constructed the first device (although it was bulky and awkward), based on the early studies of L. Nicolai, for continuous monitoring of blood saturation in the ear and in some other organs and tissues. K. Matthes and F. Gross were the first to use a second wavelength (blue-green, or infrared in later devices) which is not dependent on oxygen saturation to compensate absorbance variation related to tissue thickness, blood volume, incident light intensity, tissue pigmentation, etc.

The invention of oximetry in the United States and Great Britain was associated with the needs of aviation during World War II, because airplane cockpits were not air-tight. The first description of a transcutaneous oximeter was reported in 1940 by J. R. Squire from London University College Hospital. He used the following procedure of measurements. The tissue of the arm was squeezed with a cuff for maximum removal of blood, and zero readings were then recorded in two optical ranges (red and infrared). Then, the cuff was removed, and the increased light absorption induced by the restoration of blood circulation was recorded. This technique did not gain wide ground for some purely technical reasons. A similar oximeter was reported in 1942 by the Scottish researcher E. A. G. Goldie. An "oxyhemoglobinograph" based on a red light source and a photoelectric tube was designed by F. W. Hartman and R. D. McClure from Detroit. Between 1940 and 1942, G. A. Millikan constructed an ear oximeter intended to meet the requirements of practical aviation. He also introduced the term "oximeter". From 1946, he