X-ray diagnostics in non-specialized conditions

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Abstract. The results of research in the development of X-ray diagnostic equipment in non-specialized conditions are described. The design of the first domestic digital X-ray diagnostic complex for neonatology in portable design is presented. Examples of X-ray images obtained “at home” from a patient are given.

1. Introduction
Currently, all the more urgent becomes the problem of X-ray studies in an unspecialized conditions, such as patient “at home” [1, 2]. Reasons for conducting X-ray diagnostic studies at home may be different, including:

- somatic “serious” condition in elderly patients who are unable to get to the health facility for suspected pneumonia, fractured limbs, other trauma, etc.;
- availability of financial well-off citizens, which ready to pay for X-ray diagnostic “at home”.

However, in many cases, X-ray radiography in unspecialized conditions cannot be regarded as a method of definitive diagnosis, since there is a number of specific restrictions in carrying out such researches. At first, often medical condition of patient does not allow to perform X-ray examination in the standard (at least 2) projections; secondly, the characteristics of the technical means of X-ray radiology, do not allow conduct the X-ray studies.

Obviously, the use of traditional stationary tripod devices providing positioning X-ray apparatus relative to the patient, at home is not possible. Therefore, staff use portable tripods or takes the picture without using a tripod – “in hand”. Therefore, special importance becomes the issue of radiation safety for the staff carrying out the study, and to the others who may also be involved in the study, such as the laying of the patient. However, the use of stationary means of protection against the unused X-ray radiation, as well as remove others at a safe distance in the home is almost impossible. Therefore it is necessary to use such a technique of X-ray photography, which can significantly reduce the exposure dose of radiation than when using stationary devices. In this case, is extremely important to increase the image quality of the test authority, the necessary and sufficient for a decision of the presence or absence of pathology.

Of particular importance to the issue of X-ray diagnostics in unspecialized conditions gives the important challenges of modern clinic – radiological surveys in neonatology. Additional difficulties in
its decision are caused by the small size and weight of the newborn (up 400 g); conditions in which there is a child (incubator, open resuscitation system, operating), as well as the severity of his condition (reanimation, intensive care, rehabilitation). Often, because of the condition of the patient: artificial ventilation, cardiac or infusion therapy, active aspiration – X-ray study can be conduct only in the reanimation.

According “City Children's Hospital № 1” (Saint Petersburg) only in its resuscitation units annually around 4500 radiographic procedures in 2 or 3 projections. In total, it is up to 10 thousand X-rays in a year. Currently, these studies are carried out on the domestic or foreign X-ray machines, practically not adapted to the problems and conditions of the resuscitation of newborns with pathologies. Accordingly, the additional radiation load subjected to medical staff and other patients.

Research carried out in collaboration with experts from Federal Almazov North-West Medical Research Centre and “City Children's Hospital № 1” showed that virtually all requirements to the organization of the X-ray studies in unspecialized environment and, above all, neonatology, satisfied by method of microfocus X-ray radiography. Its main features are:

- using X-ray apparatus with a size of focal spot of X-ray tube is less than 0.1 mm;
- 1.5–2 fold increase voltage on X-ray tube and 3–5 times decrease focal distance as compared to standard X-ray technique.

To implement a methodology was developed specialized digital X-ray diagnostic complex “PARDUS-Neo” composed of the X-ray apparatus “PARDUS” in a portable version and X-ray visualisation system on the basis of the screen with the photoluminophore. The construction of the first domestic portable apparatus “PARDUS-R” allows to obtain X-ray images without the use of a stationary tripod. X-ray lab assistant takes a picture while holding the device in hand, while being in the radiation safety conditions (figure 1).

![Figure 1. Portable X-ray apparatus “PARDUS-R”](image1)

Figure 2 shows an X-ray image of the preparation of the newborn body obtained by the method of microfocus X-ray radiography in unspecialized conditions on the X-ray diagnostic complex “PARDUS-Neo”.

![Figure 2. X-ray image of the preparation of the newborn body](image2)
On the X-ray image is good visualized structure of bone elements: bone of the skull base, thorax skeleton, spine, pelvis and long bones, and soft tissues, including non-contrast nasotracheal tube. Figure 3 shows the X-ray images of the thoracic department (patient P., age 7 months, weight 3.5 kg), obtained in a stationary X-ray room in “City Children's Hospital № 1” (Figure 3(a)), and obtained in unspecialized conditions “at home” of the same patient (figure 3(b)) using the complex “PARDUS-Neo”. An radiograph of pelvic colon of the same patient is shown in figure 4. According to experts the informativeness of the X-ray image obtained at home, almost as good as X-ray image obtained in the hospital.

![Figure 3. X-ray images of the thoracic department: (a) – stationary X-ray room in “City Children's Hospital № 1”; (b) – unspecialized conditions “at home” using the complex “PARDUS-Neo”.](image)

![Figure 4. X-ray image of the lumbar spine and pelvic colon, obtained at the “home” of the patient.](image)
Thus, the described results of research open the prospect of the use of techniques of microfocus X-ray portable technical equipment for newborns research.

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References
[1] Potrakhov N N 2015 Biomedical Engineering 48 237–40
[2] Potrakhov N N and Potrakhov Yu N 2017 Biomedical Engineering 50 406–9