The Journal of Neurological and Neurosurgical Nursing
Pielęgniarstwo Neurologiczne i Neurochirurgiczne

Wydawnictwo Państwowej Akademii Nauk Stosowanych we Włocławku
ul. Mechaników 3, pok. 20
87-800 Włocławek

eISSN 2299-0321 ISSN 2084-8021
https://apcz.umk.pl/PNIN

DOI: 10.15225/PNN.2024.13.1.5 JNNN 2024;13(1):29–35 **Original**

Acquisition and Development of Scrub Nursing Skills in Robotic-Assisted Cranial and Spinal Neurosurgical Procedures

Wdrażanie i rozwój umiejętności instrumentacji w zabiegach robotycznych z zakresu neurochirurgii głowy i kręgosłupa

Jolanta Piszczela[1], Justyna Łuczyk[1], Barbara Byjoś[1], Dorota Drewniak[1], Jacek Szczygielski[1–3]

1 St. Queen Jadwiga Regional Clinical Hospital No 2 in Rzeszów, Poland
2 Institute of Medical Sciences, University of Rzeszów, Poland
3 Department of Neurosurgery, Saarland University Medical Center and Saarland University Faculty of Medicine, Homburg/Saar, Germany

Abstract

Introduction. In high-tech operative specialties, including neurosurgery, the rise of interest in robotic systems is observed, since these techniques are hoped to increase the precision of the operation. However, for the optimal implementation of these solutions, the close cooperation between surgeon and perioperative nursing team as well as adequate coordination of their actions is required. These skills needs to be gained and trained.
Aim. The following report describes the single center experience of the operating team in launching the robotic navigation in neurosurgical procedures from the vantage point of nursing team.
Material and Methods. This work contains a phenomenological analysis of learning process and of optimalisation in cooperating the work of the involved operating team during early phase of introducing the robotic neurosurgical procedures (both cranial and spinal). Here, the typical problems during implementation of these techniques with separate analysis of single steps of preparing and applying the tool sets are described, where critical points and the potential of failure elimination is highlighted.
Results. The preparing of the robotic surgical tool set is not demanding and differs only slightly from the preparation of standard sets designed for neuronavigation plus targeted cranial biopsy or percutaneous spine instrumentation, respectively. The key point is to synchronize the actions of the operating surgeon (-s), perioperative nurses and radiologic technicians.
Conclusions. Implementation of robotic techniques is a challenge for the whole neurosurgical team, including the scrub/circulating nurses. What is more important in the initial phase than (usually intuitive) operation of the devices, is the coordination of single team members' actions and developing the communication skills regarding the planned course of the surgery and potential modification of its course, needed before the surgery starts. **(JNNN 2024;13(1):29–35)**
Key Words: neurosurgery, operative nursing, robotic scrub nursing

Streszczenie

Wstęp. W operacyjnych dyscyplinach wysokospecjalistycznych, jak np. w neurochirurgii obserwuje się coraz szersze stosowanie rozwiązań operacyjnych, opartych na technikach robotycznych. Budzą one wielkie zainteresowanie i nadzieję zwiększenia precyzji przeprowadzanych zabiegów. Do pełnego wykorzystania tych technik niezbędna jest pełna współpraca operatora z zespołem instrumentującym oraz dobra koordynacja ich działań. Ta umiejętność wymaga odpowiedniego szkolenia i wdrażania.
Cel. Poniższe opracowanie opisuje doświadczenie we wstępnej fazie wprowadzania technik robotycznych z punktu widzenia pielęgniarstwa operacyjnego.

Materiał i metody. Poniższe opracowanie zawiera fenomenologiczną analizę procesu uczenia się oraz usprawniania współpracy zespołu operacyjnego przy zabiegach z użyciem neurochirurgicznego robota operacyjnego w trakcie wdrażania technik operacyjnych z zakresu chirurgii głowy i kręgosłupa. Opisane są tutaj typowe problemy w implementacji tego typu zabiegów z wyróżnieniem poszczególnych faz przygotowania i zastosowania instrumentarium z wyszczególnionymi punktami krytycznymi i możliwościami wyeliminowania ryzyka niepowodzenia.
Wyniki. Samo przygotowanie instrumentarium robotycznego nie stanowi wyzwania i odbiega tylko nieznacznie stopniem komplikacji od przygotowania typowego sterylnego zestawu do neuronawigacji oraz odpowiednio biopsji celowanej (dla zabiegów czaszkowych) lub stabilizacji przezskórnej (dla zabiegów kręgosłupowych). Kluczowym punktem jest synchronizacja działań operatora/operatorów, zespołu instrumentującego oraz techników radiologicznych.
Wnioski. Wdrażanie technik operacji robotycznych stanowi wyzwanie dla całego zespołu neurochirurgicznego, włączając zakres czynności pielęgniarstwa operacyjnego. W fazie wstępnej bardziej istotna od (często intuicyjnych) rozwiązań technicznych i opanowania obsługi poszczególnych elementów wyposażenia jest koordynacja pracy zespołu oraz opracowanie rozbudowanego sposobu komunikacji przedoperacyjnej na temat planowanej strategii zabiegu oraz możliwych zmian i odstępstw od przewidzianego planu. **(PNN 2024;13(1):29–35)**
Słowa kluczowe: neurochirurgia, pielęgniarstwo operacyjne, instrumentacja robotyczna

Introduction

Current progress in operative techniques used in neurosurgery demands constant adaptation of the whole surgical team to the innovative devices and setup. In particular, implementing the new operative tools and new pieces of equipment (sometimes quite complex and with specific handling) is a demanding task. One example of the surgical branch, requiring particular device investment is robotic surgery. In area of operative neurosurgery, the robots were introduce first for improvement of navigation-guided insertion of different implants in spinal surgery [1,2]. Meanwhile, the branch is quickly developing and several centers are involved in performing both spinal and cranial surgeries [3–6]. There are several technical solutions available on the market of robotic neurosurgery, all joined by the general principle of action. Different to other robotic surgery fields, in neurosurgery the robot usually is not performing any action — controlled or automated — on the patient's body but is a mere an extremely precise navigation tool, enabling to plan exactly the surgical trajectory, along which the implant or e.g. biopsy needle is protruded into the living tissue of a patient during the surgical maneuver [7]. By fulfilling this task, the neurosurgical robots are reputedly increasing the precision of the surgery and of surgeons' confidence in performing the procedure and reducing the invasiveness of the operation [1,8,9]. By the same time, the duration of the procedure seems to be not prolonged [1,10,11]. However, to achieve these goals, a well-trained and well prepared surgical team composed of neurosurgeon, radiology technician and both scrub (also described: robotic) nurse and circulating nurse is required [12].

Implementing the new techniques is a challenging task for each neurosurgical center launching the robotic procedures. However, due to the novelty of the concept, the number and content of relevant information sources supporting the scrub nursing teams remains very scarce. In particular, the exchange of experience regarding the introduction and sustaining the new professional and interpersonal skills is limited to mainly surgical aspects of this topic. In order to fill this gap, we aimed to gather and analyze the experience of our neurosurgical interdisciplinary team on the first steps of introduction of robotic procedures. Here, the main aim of the paper is to provide the target audience with some hints that may be essential in building up the robotic scrub nursing team while avoiding some potential beginner's mistakes. In order to achieve this goal, we are sharing n this observational report the own experience of our center in introducing the robotic techniques in all-day practice of scrub nursing team.

Material and Methods

The presented material refers to observations made and noticed by the whole surgical team during the introductory phase of using the robotic system designed for neurosurgical procedures. Starting in spring 2022, the plan of purchasing and implementing the robotic system ExcelsiusGPS® Robotic Navigation Platform produced by Globus Medical has been conducted in St. Queen Jadwiga Clinical Regional Hospital No 2 in Rzeszów. After the purchasing, the complimentary series of introductory dry-runs (2 for spinal procedures, 2 for cranial procedures, about 3h each) have been conducted, followed by surgical procedures accompanied by medical representatives of the producer's company (first 5 neurosurgical procedures). During dry-runs the potential pitfalls in preparation of navigation/robotic device and in preparing the instrument sets required for the robotic neurosurgical procedures were thoroughly discussed. During accompanied procedures, the work flow during this preparation was supervised by medical representative, experienced both in robotic techniques and in general aspects of tutoring in scrub nursing. Here, the potential of wrong preparation of the instruments or their misuse was eliminated by the supervising person. Thereafter, about 10 consecutive surgeries, including both spinal and cranial operations were conducted by the surgical team independently (without the need of participation of supervising representative of the company). All aspects of both potential pitfalls and near-by failures were discussed by the whole surgical team during the debriefing. The conclusions of both learning period as well as of single debriefings performed after each surgical procedure were collected and summarized in the following description.

Results

The Figure 1 demonstrates the robotic navigation system prepared for working. It consists of main unit, equipped with the robotic arm, which due to the free movement around the patient is able to provide the adequate trajectory to the invasive tools. On the top, the main unit carries a large size touch screen, which enables the surgeon to operate the navigation system during the process of preparation and — after sterile draping — during the procedure itself. A subunit is stand-alone system of cameras, recording the coordinates in the virtual space of the operating theatre, based on the principle of infrared reading from the markers/fiducials attached to the reference frame or single tools.

One of the main concerns, is the proper position of the main unit and the subunit. For the appropriate work of the device, without unnecessary delays in surgical performance, an unobscured view of the camera subunit on the surgical field or at least on the reference frames is necessary. Here, not only positioning of the scrub table or scrub nurse itself but also of the X-ray C-arm scanner is crucial for the performance during robotic assisted operation. For both types of procedure (cranial and spinal), intraoperative CT-scan after initial setup and preparation is required. Here, the key feature is the adaptation of operating table with the patients lying on it in prone position (for lumbar spinal procedures) or in supine position with the head secured in three-point fixation (radiolucent, carbon-made Mayfield frame). Already at the stage of positioning of the patient, appropriate space reserve for the subsequent C-frame scanning needs to be calculated.

Figure 2 and 3 demonstrate the standard set of surgical tools used during the procedure of, respectively, targeted biopsy of brain and during the procedure of spinal stabilization. As seen on the Figure 2, the spectrum of necessary sterilized tools is limited to reference star, navigation pointer, skin incision pointer and high-speed drill with distance limiter. The main working tool is the biopsy needle, which — in its shape and function — does not vary from standard Sedan-type side-cutting needle and is equipped with the reference fiducials, allowing live verification of accuracy during advancing the needle

Figure 1. Photograph demonstrating the robotic navigation system. The whole device consists of part main unit (body) of the device (1) carrying the robotic arm, defining the trajectory of the surgical instruments (2). On the top of the main unit there is a touch screen (3) which enables the surgeon to operate the equipment during the procedure. Separate, cable-connected part is the navigation camera subunit (4) devised as stand-alone system placed usually behind the operation field

Source: Property of authors

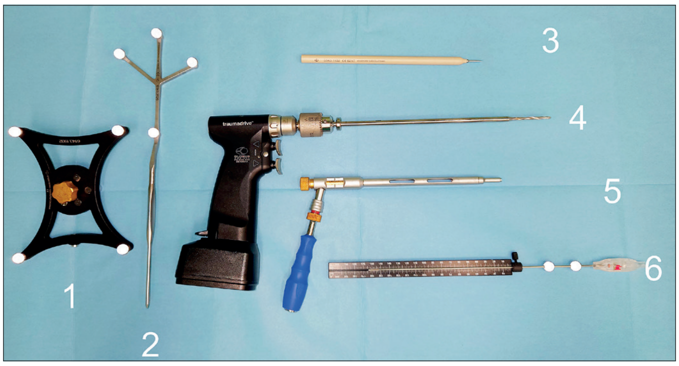

Figure 2. Photograph demonstrating the surgical instrument set necessary to perform cranial robotic biopsy. The main components are neuronavigation frame (1) and pointer (2), both equipped with fiducials, recognized by navigation camera system. The tools inserted via robotic arm are the pointer for the prick scarification of the skin (3), drill holder enabling the regulation of the trephination depth (4) and the drill itself (5). The main tool, biopsy needle of Sedan type (6) is also equipped with fiducials i.e. is navigable and the progress of the biopsy is visible on the robot device screen

Source: Property of authors

Figure 3. Photograph illustrating the complexity of the set used during robotic spinal procedures. Here, the main three parts/components of the set may be distinguished: tools used for performing the approach for e.g. initial surgical decompression or for skin incision before inserting the implants (1); the selection of tools used for the transpedicular cannulation of vertebral bodies prior to screw implantation (2), note that most of the tools are carrying the fiducial reference miniframes i.e. are navigable; the part (3) of the set consist of the spinal implants (screws and rods) designed for minimally invasive surgical implantation

Source: Property of authors

into biopsy site. The risk of e.g. mixing up the instruments is here limited and, after acquisition of initial CT, required for neuronavigation the progress of the operation, including targeted skin incision, drilling the skull and performing the biopsy is quite straightforward. Thus, the main challenge for nursing team is limited to the appropriate preparing of the device itself (including adequate sterile coverage of the robotic arm and touchscreen), its placement in operating room (OR) and handing out the biopsy instruments in adequate (short) sequence. For this reason, the learning curve for the cranial robotic procedures is much steeper=more convenient for introducing this type of operations into the team.

The spinal procedures, on the other hand are more complex as to the number and variety of instruments used during the procedure (see Figure 3). However, key feature of the set of instruments is that the typical tools and implants used for the minimally invasive surgical (MIS) implantation of both spinal screws and cages are equipped with the reference miniframes and need to be registered by the navigation device prior to their implementation into the surgical field. Thus, the apparent complexity of the set is not much higher than regular MIS spinal set. Again, the additional tools are the reference frame, here fixed by the operating surgeon directly to the patient's body (usually iliac crest) [13] and navigation pointer. Also here, as in cranial procedures, the role of scrub (robotic nurse) and circulating nurse, both setting the main device and assembling the OR space relies on anticipation, what will be the trajectory of navigation infrared beam in order to avoid potential obscuring it (what unnecessary prolongs the surgery). Here, according to the own observation the learning curve may be more flat i.e. the whole operating team, in particular in regard to scrub nurse may demand longer time/more repetitions or dry runs to imprint the sequence of events and master the whole procedure. This is particularly the true, if the team is not familiar with techniques of spinal MIS instrumentation and both aspects i.e MIS and robotic navigation need to be trained simultaneously.

Another important aspect is the coordination of work between surgical team (surgeon, scrub nurse and circulatory nurse) and X-ray technician and anesthesiology team. Again, the spinal surgeries are more demanding, since for precision in screw placement, a short periods of apnoe (about several seconds) need to be performed during every (re-) adjustment of working trajectory. This means, that the time span for implementation of the given tool is limited. The proper synchronization of tool exchange between surgeon and scrub nurse poses a particular challenge for the whole team and needs to be trained during the several dry runs in order to avoid unnecessary and deleterious prolongation of apnoe phases during the operation.

Next point is the potential modification of surgery plan. In case of intraoperative, intracranial bleeding the need for conversion from targeted biopsy to the form of open surgery (craniotomy and potentially use of operative microscope) may appear. In practice, this potential should be mentioned already during preparation and before the surgery starts, in order to e.g. assure the availability of the neurosurgical microscope. The same aspect regards the spinal procedures, where e.g. the initial phase of the operation may rely on microsurgical decompression of spinal canal/nerve root. Here, again both availability of operative microscope and neurosurgical set dedicated for e.g. seqeusterectomy needs to be secured. Also here appropriate communication of the surgeon's expectation with the nursing team is mandatory. Here, strict following the safe surgery protocols including the appropriate team-time-out before the surgery starts is essential for such robotic/hybrid procedures.

Discussion

The main goal of our observational analysis was to document the process of introducing a new surgical technique from the perspective of scrub/circulatory nurse team. We intended to highlight the key points and pitfalls, important in launching the robotic procedures in neurosurgery. By sharing our experience we hope to facilitate the hard process of establishing the robotic techniques by other teams and centers.

With no doubt, the robotic techniques in operative medicine, including neurosurgery are novel. Thus, one of the main hurdles is a certain "fear of novelty" among the members of the team [14]. To overcome this obstacle, several benefits of robotic surgical procedures need to be listed. First, the use of robotic navigation seems to be a valid and safe alternative to the classic stereotactic procedures in cranial surgery [5,6]. Importantly for the nursing team, no significant difference in duration of procedure performed by experienced team was noted [8]. Second, in spinal surgery the navigation-guided robotic implantation of spinal stabilization is reported to be safer and provides the necessary confidentiality for the surgical team [9,15–18]. Of note, the use of robotic navigation allows to limit the radiation exposure during each procedure when adequate safety protocols are applied [19–21]. This aspect is quite relevant for both circulating and scrub nurses involved in spinal procedures [22–24]. Third, the use of robotic systems may bring some economic benefits, not only as to the time of surgery, but also as to the costs of procedures performed [25,26]. This aspects are making the robotic surgery to be inevitable part of the progress in operative surgery, including OR nursing.

Are these benefits worth of the effort put in the OR staff training? According to our experience, in particular introducing the spinal procedures to the team naïve to both robotic navigation and principles of MIS in spinal implantation may be particularly challenging. However, also cranial biopsies, technically simpler as to the general course of the procedure require certain time investment in order to make the workflow familiar to the whole team. In our opinion, the stage of several dry-runs and repetitive insight into the tool set outside the operative field is crucial for successful accomplishing the training [27,28]. Since the number of robotic assisted surgeries in the introductory phase is limited, it is also advisable to delegate a limited number of staff members to get involved in the training in order to warrant the appropriate team familiarity [28–32], while on the latter stage, this knowledge and skills may be disseminated among the further team members on the basis of direct (scrub nurse) and secondary (circulating nurse) participation in the procedures. From the past perspective, the methods of virtual training (e.g. virtual reality simulation) may be a viable and valuable option for the beginning of the learning process [33,34].

One important aspect of robotic operations in neurosurgery is the interaction between team members. Contrasting to e.g. urologic or laparoscopic operative techniques, the surgeon is controlling the robotic device not remotely, but actively takes part in performing single step of the procedure and the principle of both scrub and circulating nurse assistance is the same as during the classical neurosurgical procedures [35–37]. For this reason, the limited communication (both verbal and non-verbal) between team members is here not an issue [38,39]. However, the introducing new tools and customizing the sequence of its use is paramount for the success while instituting the robotic procedures in the neurosurgery. Nevertheless, the team dedicated for the robotic procedures should also possess adequate experience in the regular neurosurgical procedures. On the one hand, it enables to deal with the technical or logistic emergencies requiring e.g. conversion from robotic to microsurgical procedures [21,40]. On the other hand, this variety of skills fuels the team creativity, enabling to develop new strategies and/or hybrid surgical techniques [4,41,42].

Conclusions

Our experience shared by this publication demonstrates the "stony road" of introducing the robotic neurosurgical procedures among the perioperative nurse team, previously not involved in these types of procedures. In particular, on the beginning of this road, the number of pitfalls and potential of technical failure or simple resistance to novelty is significant. However, the systematic training approach, including several dry-runs, getting familiar with the tools aside of the operative procedure and stepwise expanding the spectrum of performed surgeries are the keys to succeed on this path. Still, the target of safe and confident participation in the cutting-edge operative techniques is quite attractive for all members of the neurosurgical operative team.

Implications for Nursing Practice

Implementation of new robotic techniques in the setting of neurosurgical operative facilities is feasible even for the teams naïve to these type of procedures. However, certain stamina in training, several dry-runs of preparation of both robotic device and surgical instruments as well as the initial support of the technical representatives is necessary for the successful and safe implementation of new procedures. The fear of novelty alone should not be the obstacle in introducing the new operative techniques. In the initial phase of robotic surgery implementation, the consolidation of the core scrub nursing team and the strict cooperation with the other staff members is essential.

Acknowledgments

We gratefully acknowledge the crucial input of Hospital Administration by the acquisition of robotic surgery equipment and the constant logistic support of its use.

References

[1] Farber S.H., Pacult M.A., Godzik J. et al. Robotics in Spine Surgery: A Technical Overview and Review of Key Concepts. *Front Surg*. 2021;8:578674.
[2] McKenzie D.M., Westrup A.M., O'Neal C.M. et al. Robotics in spine surgery: A systematic review. *J Clin Neurosci*. 2021;89:1–7.
[3] Dlaka D., Švaco M., Chudy D. et al. Brain biopsy performed with the RONNA G3 system: a case study on using a novel robotic navigation device for stereotactic neurosurgery. *Int J Med Robot*. 2018;14(1).
[4] Chiu T.L., Lin S.Z., Ahmed T., Huang C.Y., Chen C.H. Pilot study of a new type of machine vision-assisted stereotactic neurosurgery for EVD placement. *Acta Neurochir (Wien)*. 2022;164(9):2385–2393.
[5] Karasin B., Hardinge T., Eskuchen L., Watkinson J. Care of the Patient Undergoing Robotic-Assisted Brain Biopsy With Stereotactic Navigation: An Overview. *AORN J*. 2022;115(3):223–236.
[6] Kronreif G., Ptacek W., Kornfeld M., Fürst M. Evaluation of robotic assistance in neurosurgical applications. *J Robot Surg*. 2012;6(1):33–39.
[7] Yuk F.J., Carr M.T., Schupper A.J. et al. Da Vinci Meets Globus Excelsius GPS: A Totally Robotic Minimally Invasive Anterior and Posterior Lumbar Fusion. *World Neurosurg*. 2023;180:29–35.
[8] Ho A.L., Pendharkar A.V., Brewster R. et al. Frameless Robot-Assisted Deep Brain Stimulation Surgery: An Initial Experience. *Oper Neurosurg (Hagerstown)*. 2019; 17(4):424–431.
[9] Jiang B., Karim Ahmed A., Zygourakis C.C. et al. Pedicle screw accuracy assessment in ExcelsiusGPS® robotic spine surgery: evaluation of deviation from pre-planned trajectory. *Chin Neurosurg J*. 2018;4:23.
[10] Anderson W., Ponce F.A., Kinsman M.J. et al. Robotic-Assisted Navigation for Stereotactic Neurosurgery: A Cadaveric Investigation of Accuracy, Time, and Radiation. *Oper Neurosurg (Hagerstown)*. 2023.
[11] Minchev G., Kronreif G., Ptacek W. et al. Frameless Stereotactic Brain Biopsies: Comparison of Minimally Invasive Robot-Guided and Manual Arm-Based Technique. *Oper Neurosurg (Hagerstown)*. 2020;19(3): 292–301.
[12] Russell B. Understanding the role of the scrub nurse during robotic surgery. *Nurs Stand*. 2022;37(12):71–75.
[13] Judy B.F., Soriano-Baron H., Jin Y. et al. Pearls and pitfalls of posterior superior iliac spine reference frame placement for spinal navigation: cadaveric series. *J Neurosurg Case Lessons*. 2022;3(9):CASE21621.
[14] Palese A., Infanti S. The experiences of nurses who participate in awake craniotomy procedures. *AORN J*. 2006;84(5):811–826.
[15] Kanaly C.W., Backes D.M., Toossi N., Bucklen B. Robotic-assisted spine surgery allows for increased pedicle screw sizes while still improving safety as indicated by elevated triggered electromyographic thresholds. *J Robot Surg*. 2023;17(3):1007–1012.
[16] Toossi N., Vardiman A.B., Benech C.A. et al. Factors Affecting the Accuracy of Pedicle Screw Placement in Robot-Assisted Surgery: A Multicenter Study. *Spine (Phila Pa 1976)*. 2022;47(23):1613–1619.
[17] Vardiman A.B., Wallace D.J., Booher G.A. et al. Does the accuracy of pedicle screw placement differ between the attending surgeon and resident in navigated robotic-assisted minimally invasive spine surgery? *J Robot Surg*. 2020;14(4):567–572.
[18] Vardiman A.B., Wallace D.J., Booher G.A., Toossi N., Bucklen B.S. Decreasing the Pedicle Screw Misplacement Rate in the Thoracic Spine With Robot-guided Navigation. *Clin Spine Surg*. 2023;36(10):431–437.
[19] Schuetze K., Kraus M., Eickhoff A., Gebhard F., Richter P.H. Radiation exposure for intraoperative 3D scans in a hybrid operating room: how to reduce radiation exposure for the surgical team. *Int J Comput Assist Radiol Surg*. 2018;13(8):1291–1300.
[20] Vaccaro A.R., Harris J.A., Hussain M.M. et al. Assessment of Surgical Procedural Time, Pedicle Screw Accuracy, and Clinician Radiation Exposure of a Novel Robotic Navigation System Compared With Conventional Open and Percutaneous Freehand Techniques: A Cadaveric Investigation. *Global Spine J*. 2020;10(7):814–825.
[21] Zygourakis C.C., Ahmed A.K., Kalb S. et al. Technique: open lumbar decompression and fusion with the Excelsius GPS robot. *Neurosurg Focus*. 2018;45(VideoSuppl1):V6.
[22] Godzik J., Mastorakos G.M., Nayar G., Hunter W.D., Tumialán L.M. Surgeon and staff radiation exposure in minimally invasive spinal surgery: prospective series using a personal dosimeter. *J Neurosurg Spine*. 2020;1–7.
[23] Hubbe U., Sircar R., Scheiwe C. et al. Surgeon, staff, and patient radiation exposure in minimally invasive transforaminal lumbar interbody fusion: impact of 3D fluoroscopy-based navigation partially replacing conventional fluoroscopy: study protocol for a randomized controlled trial. *Trials*. 2015;16:142.
[24] Klingler J.H., Scholz C., Hohenhaus M. et al. Radiation Exposure to Scrub Nurse, Assistant Surgeon, and Anesthetist in Minimally Invasive Spinal Fusion Surgery Comparing 2D Conventional Fluoroscopy With 3D Fluoroscopy-based Navigation: A Randomized Controlled Trial. *Clin Spine Surg*. 2021;34(4):E211–E215.
[25] Soliman M.A.R., Pollina J., Poelstra K., Chaudhary S., Foley K. Can a Spine Robot Be More Efficient and Less Expensive While Maintaining Accuracy? *Int J Spine Surg*. 2022;16(S2):S50–S54.
[26] Menger R.P., Savardekar A.R., Farokhi F., Sin A. A Cost-Effectiveness Analysis of the Integration of Robotic Spine Technology in Spine Surgery. *Neurospine*. 2018;15(3):216 –224.

[27] Sarmanian J.D. Robot-Assisted Thoracic Surgery (RATS): Perioperative Nursing Professional Development Program. *AORN J*. 2015;102(3):241–253.
[28] Vigo F., Egg R., Schoetzau A. et al. An interdisciplinary team-training protocol for robotic gynecologic surgery improves operating time and costs: analysis of a 4-year experience in a university hospital setting. *J Robot Surg*. 2022;16(1):89–96.
[29] Henaux P.L., Michinov E., Rochat J., Hémon B., Jannin P., Riffaud L. Relationships Between Expertise, Crew Familiarity and Surgical Workflow Disruptions: An Observational Study. *World J Surg*. 2019;43(2):431–438.
[30] Hill A.L., Scherer M.D., Kiani A. et al. The impact of a dedicated operating room team on robotic transplant program growth and fellowship training. *Clin Transplant*. 2023;37(11):e15103.
[31] Ortiz Oshiro E., Ramos Carrasco A., Moreno Sierra J. et al. Desarrollo multidisciplinario de la cirugía robótica en un hospital universitario de tercer nivel: organización y resultados. *Cir Esp*. 2010;87(2):95–100.
[32] Witmer H.D.D., Keçeli Ç., Morris-Levenson J.A. et al. Operative Team Familiarity and Specialization at an Academic Medical Center. *Ann Surg*. 2023;277(5):e1006–e1017.
[33] Ballas D., Cesta M., Roulette G.D., Rusnak M., Ahmed R. Emergency Undocking in Robotic Surgery: A Simulation Curriculum. *J Vis Exp*. 2018;(135):57286.
[34] Bracq M.S., Michinov E., Arnaldi B. et al. Learning procedural skills with a virtual reality simulator: An acceptability study. *Nurse Educ Today*. 2019;79:153–160.
[35] Abdel Raheem A., Song H.J., Chang K.D., Choi Y.D., Rha K.H. Robotic nurse duties in the urology operative room: 11 years of experience. *Asian J Urol*. 2017;4(2):116–123.
[36] Cavuoto L.A., Hussein A.A., Vasan V. et al. Improving Teamwork: Evaluating Workload of Surgical Team During Robot-assisted Surgery. *Urology*. 2017;107:120–125.
[37] Haig F., Medeiros A.C.B., Chitty K., Slack M. Usability assessment of Versius, a new robot-assisted surgical device for use in minimal access surgery. *BMJ Surg Interv Health Technol*. 2020;2(1):e000028.
[38] Almeras C., Almeras C. Operating room communication in robotic surgery: Place, modalities and evolution of a safe system of interaction. *J Visc Surg*. 2019;156(5):397–403.
[39] Tiferes J., Hussein A.A., Bisantz A. et al. Are gestures worth a thousand words? Verbal and nonverbal communication during robot-assisted surgery. *Appl Ergon*. 2019;78:251–262.
[40] Crawford N., Johnson N., Theodore N. Ensuring navigation integrity using robotics in spine surgery. *J Robot Surg*. 2020;14(1):177–183.
[41] Calisto A., Dorfmüller G., Fohlen M., Bulteau C., Conti A., Delalande O. Endoscopic disconnection of hypothalamic hamartomas: safety and feasibility of robot-assisted, thulium laser-based procedures. *J Neurosurg Pediatr*. 2014;14(6):563–572.
[42] Zimmermann M., Krishnan R., Raabe A., Seifert V. Robot-assisted navigated endoscopic ventriculostomy: implementation of a new technology and first clinical results. *Acta Neurochir (Wien)*. 2004;146(7):697–704.

Corresponding Author:
Jacek Szczygielski
Institute of Medical Sciences
University of Rzeszów
Warzywna 1 street, 35-310 Rzeszów, Poland
e-mail: jszczygielski@ur.edu.pl

Conflict of Interest: None
Funding: None
Author Contributions: Jolanta Piszczela[B, C, E, H], Justyna Łuczyk[B, C, H], Barbara Byjoś[B, C, H], Dorota Drewniak[B, G, H, J], Jacek Szczygielski[A, C, E–H]

A — Concept and design of research, B — Collection and/or compilation of data, C — Analysis and interpretation of data, E — Writing an article, F — Search of the literature, G — Critical article analysis, H — Approval of the final version of the article; J — Coordination of work of robotic nurse team

Received: 12.01.2024
Accepted: 10.02.2024