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Highlights

- Exposure during Spinal Surgery
- Non-invasive Spectrometric Method
- Determining Glucose Concentration
- Radiology Reports and Patient Education

Discovering Thoughts, Inventing Future

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Non-Invasive Spectrometric Method for Determining Glucose Concentration in Human Blood

By Gurevich B. S. & Shapovalov V. V.

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Keywords: non-invasive glucometer, system of linear equations, wavelength-tunable light source.

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Gurevich B. S.[α] & Shapovalov V. V.[σ]

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Keywords: non-invasive glucometer, system of linear equations, wavelength-tunable light source.

I. Introduction

Currently, the most promising non-invasive methods for determining blood glucose levels are considered to be optical methods based on near-infrared spectroscopy. They allow obtaining certain information about the content of various impurities in the blood, including glucose. Research in this area is quite extensive, and considerable research experience has already been accumulated [1, 2]. The main circumstance that makes it difficult to obtain objective data when implementing the spectroscopic method is that the wavelength band of light absorbed by glucose significantly overlaps with the absorption band characteristic of water and other substances contained in human skin and tissues. As a result, it is difficult to determine the proportion of light absorbed by glucose. This problem can be solved by repeated photometry at many randomly selected points in the spectrum, within which the absorption of light by glucose and other absorbing components overlaps.

An important factor is that the spectral characteristics of all absorbing agents (glucose, water, melanin, and other substances contained in blood and tissues) are generally well known. In some cases, spectral absorption curves require refinement, so when developing a glucometer based on the measurement of absorbed light, it is necessary to perform preliminary calibration measurements of the spectral characteristics of the absorption of certain absorbing components [3].

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II. Description of the Method

Let us consider light absorption in a human blood-containing organ. The Bouguer-Lambert-Beer law formula is used to describe light absorption.

$$I(l) = I_0 e^{-k_\lambda l}, \qquad (1)$$

where $I(l)$ is the intensity of light passing through a layer of material with a thickness of l, I_0 is the intensity of light at the entrance to the material, and k_λ is the absorption coefficient of the material.

However, light is absorbed by many substances as it passes through the blood-containing organs of the human body, so it is advisable to consider the following modified formula

$$I_0 = I e^{k_m n_m + k_p n_p + \cdots + k_z n_z}, \qquad (2)$$

where k_m is the absorption coefficient of component m at i-th wavelength in the layer (dimensionless quantity); n_m is the concentration of component m distributed over the layer thickness l_v. It is assumed that the layer thickness is known and constant.

After some transformations, we obtain a linear equation of the form

$$k_m n_m + k_p n_p + \cdots + k_z n_z = \ln \frac{I_0}{I}. \qquad (3)$$

If measurements are taken at N wavelengths within the spectral range of the device, then for each measurement, an equation with N unknowns can be written. As a result, we can obtain a system of N linear equations with N unknowns, which can be solved using software. One of the solutions to this system of equations will be the concentration of glucose in the blood. An approximate form of this system of linear equations is shown below:

$$\begin{cases} k_{1m} n_m + k_{1p} n_p + \cdots + k_{1z} n_z = \ln \frac{I_{10}}{I_1} \\ k_{2m} n_m + k_{2p} n_p + \cdots + k_{2z} n_z = \ln \frac{I_{20}}{I_2} \\ \quad \cdots \\ k_{am} n_m + k_{ap} n_p + \cdots + k_{az} n_z = \ln \frac{I_{a0}}{I_a} \end{cases} \qquad (4)$$

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This system can be solved by applying the Gauss method with sequential elimination of unknown variables. This solution can be obtained using standard software.

III. Features of the Instrumental Implementation of the Method

The most important condition for the instrumental implementation of the method under consideration is the use of a polychromatic light source with a programmatically variable wavelength [4]. The trend toward increasing the performance of biomedical spectrophotometers, including those used to determine blood glucose levels, necessitates the development of light sources that would allow single analyses to be performed in tens to hundreds of microseconds. Obviously, the transition from one wavelength of light to another can only be achieved by software. The required speed of switching the device from one wavelength of light to another can only be achieved if LEDs are used as the physical light source. At the same time, since the radiation band of LEDs is quite narrow (on average 30 nm), a set of LEDs is required whose spectral characteristics would completely cover the entire required wavelength range. The optimal design of a light source with a controllable spectrum for spectrophotometers involves the special localization of LEDs inside the common housing of the light-emitting unit [4].

One of the schemes in accordance with patent [4] is the light source shown in Figure 1. Such a source consists of a computer-controlled power supply unit that supplies current to the LEDs in accordance with signals received from the computer. This makes it possible to control the intensity and spectral composition of the radiation due to the ability to turn on the LEDs in any sequence, change the current supplied to any of the LEDs, and turn on several arbitrary LEDs with a given intensity.

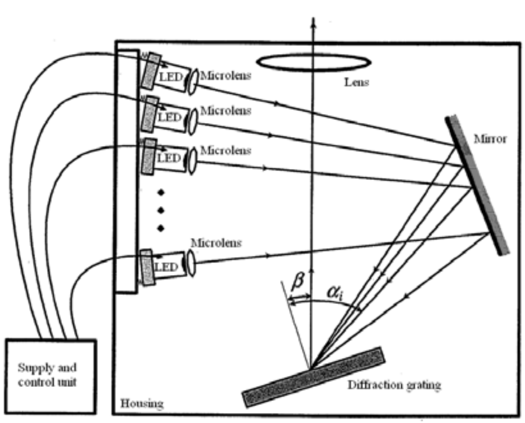

Fig. 1: Configuration of optical elements of a polychromatic light source with software control

The micro-optical assembly allows the radiation from each of the LEDs to be focused onto a mirror, which reflects this radiation onto a diffraction grating. The mirror serves to reduce the size of the device. The radiation from each of the LEDs, reflected from the mirror, hits the diffraction grating in such a way that the following condition is satisfied for each of the rays.

$$d(\sin\alpha+\sin\beta)=m\lambda, \quad (5)$$

where d is the period of the diffraction element, α is the angle between the normal to the diffraction grating and the direction of propagation of radiation from the light-emitting element, λ is the wavelength of radiation, β is the diffraction angle measured relative to the normal to the diffraction element, m is an integer that characterizes the diffraction order.

Thus, at the output of the described device, a beam propagates along a single optical axis, combining the radiation of a set of LEDs with different wavelengths of light.

Light from a polychromatic source is collected in an optical fiber and directed to a blood-containing organ, which in this case is the patient's earlobe. To introduce light into the earlobe and record unabsorbed light, a clip design was developed, which is shown in Figure 2. The input beam of probing light is delivered through the optical fiber, and the unabsorbed light that has passed through the earlobe hits the receiving part of the clip, where the photodiode is located. The signal from the photodiode is sent to a portable computer for software processing.

Fig. 2: A clip through which a probing beam of light with an adjustable wavelength passes

IV. The Influence of the Final Bandwidth of the Light Source Radiation Beam on the Convergence of the Solution in Calculations

Regardless of how the radiation bandwidth is limited during measurements, this bandwidth is finite and can be approximated by a Gaussian curve with a maximum at the point corresponding to the wavelength of interest. Thus, in general, the spectral absorption curve of both individual components and the entire part of the human body through which the radiation passes is a mathematical convolution of the true spectral absorption curve and the aforementioned approximating Gaussian curve. That is

$$S_M(\lambda)=S_a(\lambda)\otimes e^{-(\lambda-\lambda_0)^2/\sigma^2}, \quad (6)$$

where S_M(l) is the measured spectral absorption curve, S_a is the true spectral absorption curve, l_0 is the wavelength of radiation at the point of maximum transmission bandwidth, and *s* is the transmission bandwidth. From this, it can be seen that the smaller the radiation passband width, the closer it is to the d-function and the closer the measured spectral absorption curve is to the true one.

Expression (6) is valid for the case when a single-element photodetector (such as a standard photodiode) is used, and a switchable set of physical light sources is used as the emitter, in which the central wavelengths of radiation are specified and the transmission bands have a Gaussian shape. However, if we use the circuit used in most modern spectrophotometers, then a physical light source with a wide spectrum is most often used, but with the help of a spectrally selective element, for example, diffraction grating, to spatially separate radiation with different wavelengths and direct this radiation to a multi-element photodetector, such as a CCD array. In this situation, the signal recorded by a single photosensitive element of the CCD array is described by the integral of all spectral components falling on the area of a given pixel. In this case, we can take as a useful signal that which is described by formula (6), assuming that l_0 is the wavelength corresponding to the center of a given pixel. In addition, signals corresponding to the "tails" of the Gaussian distribution from colors corresponding to neighboring pixels fall on this pixel. Thus, the intensity function of light falling on all elements of the CCD array can be described by the following expression:

$$S_M(\lambda) = \sum_{z=1}^{n} S_a(\lambda) * e^{\frac{-(\lambda-\lambda_z)^2}{\sigma 2}} - \sum_{k=1}^{n-1} S_{\text{пapk}}, \quad (7)$$

where *z* is the pixel serial number, and S_{park} is the parasitic radiation intensity falling on this pixel from the signal intended for the *k*-th pixel. This value S_{park} can be described by analogy with expression (6)

$$S_{\text{пapk}}(\lambda) = S_{ak}[\lambda - (z-k)\delta\lambda] \otimes \mathrm{e}^{-(\lambda-\lambda_k)^2/\sigma^2} \quad . \quad (8)$$

Here, S_{ak} is the light intensity corresponding to the true spectral absorption curve for the *k*-th pixel of the line. Expressions (7) and (8) fully describe the distribution of radiation intensity falling on the plane of a multi-element photodetector—a CCD array.

V. Conversion of Calculated Data into Blood Glucose Concentration

As a result of calculations in accordance with this mathematical model, we obtain the value of the conditional glucose concentration ng, but with a large number of components. At the same time, the output of the model must indicate the blood glucose concentration expressed in mmol/L. There are two possible approaches to converting the conditional concentration into a concentration expressed in mmol/L.

Approach 1 – calculated. To implement it, the following steps should be taken:

A) Determine the approximate proportion of the absorbing volume occupied by blood (e.g., blood filling the earlobe). The statistical average value of this proportion can be determined from the literature. Let us denote this value as d (a dimensionless quantity, significantly less than one).
B) Determine the glucose concentration in mmol/L. Here, we must assume that the density of the glucose solution is always within the range of 1–1.1 g/mL in real cases. Then, the glucose concentration in mmol/L can be calculated as

$$C = 10^6 \frac{n_g}{\delta M_s}$$

where M_s is the molar mass of glucose (180 g/mol). The coefficient 10^6 includes the conversion of moles to millimoles, as well as milliliters to liters.

Approach 2 – calibration. This involves obtaining the calibration value n_{gc} in accordance with this mathematical model during the first test of the module, as well as determining the calibration glucose concentration C_c in the same patient at the same time using an invasive method. The ratio C_c/n_{gc} is calculated and entered into the program for displaying the glucose concentration on the interface. Then, after each calculation of n_{gc}, the glucose concentration measured in mmol/L is displayed on the interface:

$$C = n_g \frac{C_c}{n_{gc}}$$

The choice between these two approaches can only be made after conducting comprehensive experiments with the finished device.

VI. Conclusion

The device and principle of determining blood glucose content described above make it possible to implement a non-invasive method of glucometry, but there is still no clear answer to the question of measurement accuracy. The main problem lies in ensuring the convergence of the solution of a system of N linear equations with *N* unknowns. This can be achieved by taking special measures to increase the signal-to-noise ratio during measurements. Another method is to select wavelengths for measurements so that some of the absorbing components at these wavelengths have zero absorption, which will simplify

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the system and increase the probability of convergence of the solution. It should be noted that the program that controls the operation of the device and calculates the proportion of light absorbed by glucose must be corrected to take into account the absorption by melanin and the epidermis, with appropriate adjustments for each individual patient. Thus, the method will allow the development of an inexpensive indicator device for individual use, allowing the detection of moments of exacerbation of the disease when it is necessary to seek medical help.

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Readability and Comprehension in Radiology Reports and Patient Education: A Comprehensive Review

By Dr. Bhawna Solanki, Vratika Arya, Neelam Rao Bharti, Himanshu Mishra, Dr. Ashish Kumar Shukla, Rahul Kothari & Mohit Kumar Pandey

Abstract- Readability in radiology documentation is critical for effective communication between healthcare professionals and patients. Radiology reports and Patient Education Materials (PEMs) often contain complex technical language that can hinder patient understanding, leading to potential miscommunication and reduced patient satisfaction. This article explores the significance of readability in radiology, emphasizing the importance of making these documents accessible to non-specialist audiences.

Keywords: readability, radiology documentation, patient education materials (PEMs), structured reporting, health literacy, plain language, visual aids, artificial intelligence (AI), natural language processing (NLP), patient-centered care.

GJMR-D Classification: *NLMC Code: WN 200*

READABILITYANDCOMPREHENSIONINRADIOLOGYREPORTSANDPATIENTEDUCATIONACOMPREHENSIVEREVIEW

Strictly as per the compliance and regulations of:

Readability and Comprehension in Radiology Reports and Patient Education: A Comprehensive Review

Dr. Bhawna Solanki [α], Vratika Arya [σ], Neelam Rao Bharti [ρ], Himanshu Mishra [Ѡ], Dr. Ashish Kumar Shukla [¥], Rahul Kothari [§] & Mohit Kumar Pandey [χ]

Abstract- Readability in radiology documentation is critical for effective communication between healthcare professionals and patients. Radiology reports and Patient Education Materials (PEMs) often contain complex technical language that can hinder patient understanding, leading to potential miscommunication and reduced patient satisfaction. This article explores the significance of readability in radiology, emphasizing the importance of making these documents accessible to non-specialist audiences.

The objective of this article is to review the current challenges in radiology documentation readability and explore strategies for improvement. Recent studies have identified significant issues with the complexity of radiology reports and PEMs, noting that many exceed the recommended reading levels for the general population[Carmody et al., 2019]. Additionally, the transition from narrative to structured reporting has had mixed effects on readability, highlighting the need for further research and innovation [Friedman et al., 2006].

Key findings suggest that plain language, visual aids, and interactive content can enhance the clarity of radiology documentation [Hani et al., 2018]. Moreover, AI and natural language processing (NLP) tools have shown promise in simplifying complex medical information, tailoring radiology reports to different audiences, and improving patient comprehension [Doak et al., 1996]. For instance, AI-generated summaries have improved readability without compromising the accuracy of medical information [Wang et al., 2013].

In conclusion, this article emphasizes the need for ongoing efforts to enhance the readability of radiology reports and PEMs. Collaboration between radiologists, educators, and patient advocates, along with the integration of advanced technologies, will be crucial in ensuring that radiology documentation meets the diverse needs of patients, ultimately improving patient-centered care and outcomes[Gunning, 1952].

Keywords: readability, radiology documentation, patient education materials (PEMs), structured reporting, health literacy, plain language, visual aids, artificial intelligence (AI), natural language processing (NLP), patient-centered care.

I. Introduction

a) Importance of Readability in Radiology

Readability in radiology is a critical element that influences the clarity and effectiveness of communication between healthcare professionals and patients, thereby playing a crucial role in ensuring optimal patient care. Radiology reports are often filled with technical language and complex terminology, serving as the primary tool for radiologists to convey their findings to referring physicians and, increasingly, to patients themselves. However, when these reports are not written in a manner that is easily understood, it can lead to miscommunication, confusion, and potentially detrimental outcomes for patients. Readability directly impacts the ability of healthcare providers to make informed decisions and patients' ability to comprehend their medical conditions, which is essential for shared decision-making and patient-centered care (Friedman et al., 2006)).

Clear communication in radiology is particularly important because radiology serves as the diagnostic cornerstone for many medical conditions. The interpretation of radiology reports by other healthcare professionals, including surgeons, oncologists, and primary care physicians, guides treatment plans and interventions [Mamlouk et al., 2020]. When these reports are difficult to read or understand, there is a risk of misinterpretation, which can negatively affect patient outcomes [Ziemer et al., 2017]. Moreover, as healthcare becomes more patient-centered, the direct communication of radiology results to patients has become more common. Patients, who are often not medically trained, need accessible and understandable information to engage in their care. This need for readability is even more significant in radiology, where diagnostic language can be highly specialized and technical (Carmody JB et. al).

b) Historical Context

Concerns about readability in radiology have a long history, with early studies highlighting the difficulty many patients and even healthcare professionals experience in understanding radiology reports [Blease et al., 2020]. In the mid-20th century, readability formulas such as the Flesch-Kincaid Grade Level, originally developed for educational materials, began to be applied to medical documents, including radiology reports[Flesch, 1948]. These early assessments demonstrated that many medical texts were written at a level far too advanced for the general population,

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leading to concerns about the accessibility of medical information [McLaughlin, 1969].

Over time, the concept of structured reporting emerged as a means to standardize radiology documentation and improve its clarity. Structured reporting involves the use of templates and predefined formats to ensure that all relevant information is included consistently. This approach was designed to improve communication between radiologists and other healthcare providers by making reports more organized and easier to navigate[Johnson, 2014]. While structured reporting has undoubtedly enhanced the consistency of radiology documentation, it has not always addressed the broader issue of readability, particularly for non-specialists and patients[Knight et al., 2019]. The balance between technical accuracy and readability remains a challenge.

c) Current Challenges

Despite advancements in structured reporting and the growing awareness of the importance of readability, significant challenges persist in making radiology reports and patient education materials (PEMs) accessible to non-specialists. One of the major obstacles is the continued use of medical jargon and complex terminology, which can be difficult for patients and even some healthcare providers to understand [Szabó et al., 2021]. Medical language is often precise and necessary for clinical accuracy, but it can also obscure meaning when not clearly explained. This is particularly problematic in radiology, where reports are often written at a high reading level, far exceeding the average literacy level of many patients [Bange et al., 2019].

Moreover, patient education materials, which are designed to help patients understand their medical conditions and treatment options, often suffer from similar readability issues [Weiss, 2003]. Studies have shown that many PEMs are written at a level that is too advanced for the general population, making it difficult for patients to fully grasp the information being presented to them. This is especially concerning given the growing emphasis on patient autonomy and shared decision-making in healthcare. To address these challenges, healthcare organizations have increasingly turned to readability formulas as tools to assess and improve the accessibility of written materials[Ganeshan et al., 2019].

However, readability formulas are not without their limitations. While formulas such as the Flesch-Kincaid Grade Level, SMOG Index, and Gunning Fog Index can provide useful metrics for assessing the complexity of a text, they do not always account for the specific challenges of medical language, such as the prevalence of jargon and specialized terminology [McLaughlin, 1969]. Moreover, these formulas primarily focus on surface-level features such as sentence length and word complexity, without considering the broader context of the text or the reader's background knowledge. Therefore, while readability formulas can be valuable tools in the effort to make radiology reports and PEMs more accessible, they must be used in conjunction with other strategies, such as simplifying language and providing clear explanations of medical terms, to truly enhance communication in radiology [Doak et al., 1996].

II. Readability of Radiology Reports

The readability of radiology reports is a significant factor in the effective communication of diagnostic information to healthcare professionals and patients alike. As the demand for patient-centered care grows, the readability of medical documents has become a focal point of discussion in radiology. Radiology reports are complex documents that contain a wealth of technical information, often presented in specialized medical language. The challenge lies in balancing the need for clinical accuracy with the requirement for clear, accessible communication that non-specialist audiences can understand.

a) Complexity of Radiology Language

i. Technical Jargon

Radiology is a highly technical field, and the language used in radiology reports reflects this complexity. Radiologists must convey precise diagnostic information using specific terminology, which is often unfamiliar to non-specialists, including many referring physicians and patients. The technical jargon inherent in radiology serves an important purpose: it provides clarity and precision in describing medical findings. Terms like "hyperintense," "lytic lesion," or "effusion" are used to ensure that diagnoses are communicated accurately within the medical community. However, this level of specificity can present a barrier to readability, particularly for those without a background in medicine.

One of the central challenges in radiology is striking a balance between accuracy and clarity. While technical language is necessary for conveying specific information, overreliance on jargon can obscure meaning and reduce the readability of radiology reports. For healthcare providers who may not be familiar with radiology-specific terminology, this can lead to misinterpretations and delays in patient care. Moreover, as patients increasingly have access to their medical records, including radiology reports, there is a growing need to make these documents more understandable to laypersons. Studies have shown that the average reading level of the general population is around the 7th to 8th grade, while many radiology reports are written at a much higher reading level, often above the 12th grade. This disparity highlights the need for a greater focus on readability in radiology.

ii. *The Need for Accuracy vs. Clarity*

The tension between accuracy and clarity is an ongoing concern in medical communication. Radiologists are trained to use precise language to avoid ambiguity in their diagnoses. However, this technical language can hinder comprehension for those not familiar with the field. A study by Friedman et al. (2006) highlighted the importance of simplifying medical language without sacrificing accuracy. The challenge is to find ways to present complex information in a manner that is both clinically accurate and accessible to non-specialists. This is particularly important in the context of patient-centered care, where clear communication is essential for ensuring that patients understand their diagnoses and treatment options.

b) *Structured Reporting*

i. *Historical Shift*

The shift from narrative to structured reporting in radiology represents a significant evolution in how radiology reports are produced and communicated. Traditionally, radiology reports were written in a narrative format, where radiologists would describe their findings in free-text form. While this approach allowed for flexibility and detailed descriptions, it also introduced variability in report quality and structure, leading to inconsistencies that could impact the clarity and interpretability of the information conveyed (Johnson et al., 2009).

Structured reporting was introduced as a solution to these issues, aiming to standardize the content and format of radiology reports. By using predefined templates and checklists, structured reporting helps ensure that all relevant information is included in a consistent manner. This approach not only improves the clarity and completeness of reports but also enhances communication between radiologists and referring physicians. Structured reporting has been shown to reduce errors and improve the quality of radiology reports by providing a clear framework for documentation (Hani et al., 2018).

The transition to structured reporting was driven by the need for improved clarity and consistency in radiology documentation. By organizing reports into standardized sections—such as clinical history, findings, and conclusions—structured reporting makes it easier for healthcare providers to locate and interpret the information they need. This format is particularly beneficial in busy clinical environments, where time is of the essence, and quick access to critical information is paramount (Johnson et al., 2014).

ii. *Impact on Readability*

While structured reporting has improved the organization and consistency of radiology reports, its impact on readability is more nuanced. Studies have shown that structured reports are often more concise and focused, making them easier to navigate than narrative reports. However, the use of standardized templates can also lead to reports that are overly rigid or formulaic, potentially limiting the ability of radiologists to provide detailed explanations when needed (Hani et al., 2018).

Research comparing the readability of structured and narrative reports has produced mixed results. Some studies have found that structured reports are more readable for healthcare providers because they are easier to scan for key information. However, other studies have noted that structured reports can be less flexible and may not always capture the nuances of complex cases as effectively as narrative reports (Bosmans et al., 2011). For non-specialist audiences, including patients, structured reports may still present challenges in terms of readability, particularly if they contain technical jargon that is not clearly explained.

Bosmans et al. (2011) conducted a study comparing the readability and user satisfaction of structured versus narrative reporting in radiology. They found that while structured reporting improved the overall organization and ease of use, there were still significant readability challenges, particularly related to the technical language used in the reports. The study highlighted the need for ongoing efforts to simplify language and enhance the accessibility of radiology documentation.

c) *AI-Large Language Models (AI-LLMs) in Radiology*

i. *Butler et al. (2024) Study*

The introduction of artificial intelligence (AI) and large language models (LLMs) in radiology has opened new possibilities for enhancing the readability of radiology reports. A notable study by Butler et al. (2024) explored the use of AI to improve the readability of foot and ankle radiology reports. In this study, AI algorithms were applied to structured radiology reports to assess and enhance their readability for non-specialist audiences, including patients.

Butler et al. (2024) demonstrated that AI-LLMs could be used to automatically simplify complex medical language, reduce the use of jargon, and improve sentence structure without compromising the accuracy of the diagnostic information. The study involved a comparison between traditional structured reports and AI-enhanced reports, with participants—including healthcare providers and patients—evaluating the readability and clarity of each version. The AI-enhanced reports were consistently rated as more readable and easier to understand, particularly by patients who had no medical background.

One of the key findings of the Butler et al. (2024) study was the potential of AI to bridge the gap between clinical accuracy and readability. By using natural language processing (NLP) techniques, the AI was able to identify and rephrase complex sentences, substitute medical jargon with more accessible language, and reorganize information to improve the overall flow of the report. This represents a significant advancement in the effort to make radiology reports more accessible to non-specialists, particularly in the context of patient-centered care.

ii. *Future Applications*

The success of AI in enhancing readability in foot and ankle radiology reports, as demonstrated by Butler et al. (2024), points to a broader potential for AI to improve readability across other areas of radiology. As AI-LLMs continue to evolve, their application in radiology reporting could expand to include a wide range of subspecialties, from oncology to neurology, where the complexity of medical language presents ongoing challenges to readability.

One potential future application of AI-LLMs in radiology is the development of personalized reporting. AI could be used to tailor radiology reports to the specific needs of different audiences, automatically adjusting the level of detail and complexity based on whether the report is intended for a specialist, a referring physician, or a patient. This could help ensure that all recipients of the report receive information that is both accurate and accessible to them, improving overall communication and patient outcomes.

Moreover, AI could be used to create real-time language assistance tools for radiologists as they dictate or type their reports. These tools could provide suggestions for simplifying language, flagging potential readability issues, and offering alternative phrasing that balances clinical accuracy with clarity. Such innovations could significantly enhance the readability of radiology reports, making them more user-friendly for both healthcare providers and patients.

In conclusion, the introduction of AI and large language models in radiology holds great promise for improving the readability of radiology reports. The study by Butler et al. (2024) provides a glimpse into the future of radiology reporting, where AI could play a central role in ensuring that diagnostic information is communicated clearly and effectively to all stakeholders, regardless of their level of medical expertise

III. Patient Education Materials in Radiology

Patient education materials (PEMs) in radiology are essential tools for helping patients understand their diagnostic imaging procedures, results, and associated risks. These materials, which include brochures, online resources, and written guides, aim to demystify complex radiology procedures and provide patients with the knowledge they need to make informed decisions about their healthcare. However, achieving this goal requires that PEMs are not only accurate but also accessible and easy to comprehend. The readability of these materials is a key factor in ensuring that they are effective in educating patients. Unfortunately, many PEMs in radiology are written at reading levels that exceed the average patient's comprehension ability, which can lead to confusion, anxiety, and a lack of informed consent.

a) *Readability Challenges in PEMs*

i. *Szabó et al. (2021)*

A study conducted by Szabó et al. (2021) focused on the readability challenges of radiology-specific patient education materials in Hungary. The study found that many of these PEMs were written at a level that was too complex for the average patient to understand. Specifically, the study revealed that most radiology PEMs were written at a Flesch-Kincaid grade level of 12, which is well above the recommended reading level of 6th to 8th grade for patient education materials (Szabó et al., 2021). This discrepancy between the reading level of the materials and the reading ability of the target audience presents a significant barrier to effective patient education.

The study by Szabó et al. (2021) highlighted several key challenges in the development of radiology PEMs. One of the primary issues identified was the use of technical language and medical jargon, which can be difficult for patients to understand. Additionally, the materials often included long, complex sentences that further hindered readability. These challenges are not unique to Hungary; similar issues have been identified in PEMs across different countries and healthcare systems.

The findings of Szabó et al. (2021) underscore the importance of simplifying language and reducing the complexity of sentences in PEMs to make them more accessible to patients. The study recommended that healthcare providers work with communication specialists and use readability assessment tools to ensure that PEMs are written at an appropriate reading level. By addressing these readability challenges, healthcare providers can improve patient comprehension, reduce anxiety, and promote better health outcomes.

ii. *Health Literacy Implications*

The challenges identified in the study by Szabó et al. (2021) have broader implications for health literacy, particularly for populations with lower educational levels. Health literacy, which refers to an individual's ability to obtain, process, and understand basic health information, is a critical determinant of health outcomes (Berkman et al., 2011). Patients with low health literacy are more likely to experience difficulties in understanding medical information, adhering to treatment plans, and navigating the healthcare system.

For populations with lower educational levels, the readability of PEMs is a significant barrier to accessing healthcare information. When PEMs are

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written at a level that is too complex, patients with low health literacy may struggle to understand key concepts related to their health. This can lead to misunderstandings, poor health outcomes, and increased healthcare costs. Improving the readability of radiology PEMs is essential for addressing health disparities and ensuring that all patients, regardless of their educational background, have access to clear and comprehensible health information.

b) Radiation Safety Information

i. *Delaney et al. (2021)*

Radiation safety is a critical topic in radiology, and patients often have concerns about the potential risks associated with diagnostic imaging procedures that involve radiation exposure. Patient education materials on radiation safety are intended to inform patients about the benefits and risks of these procedures, helping them make informed decisions about their care. However, a study by Delaney et al. (2021) found that the readability of radiation safety guides is often too complex for patients to fully comprehend.

The study by Delaney et al. (2021) assessed the readability of radiation safety guides using the SMOG (Simple Measure of Gobbledygook) index, which is a commonly used readability formula for health materials. The study found that the average SMOG grade level of radiation safety guides was 14, which is equivalent to a reading level of a college sophomore (Delaney et al., 2021). This is significantly higher than the recommended reading level of 8th to 10th grade for radiation safety materials. The study also noted that the high complexity of the materials, particularly the use of technical language related to radiation exposure and risk, deterred patients from fully understanding the information.

The findings of Delaney et al. (2021) suggest that there is a need for significant improvements in the readability of radiation safety guides. Simplifying language, using visual aids, and providing clear explanations of technical terms are potential strategies for improving the accessibility of these materials. By making radiation safety information more understandable, healthcare providers can help alleviate patient concerns, promote informed decision-making, and enhance overall patient safety.

c) Online Patient Education

i. *Bange et al. (2019)*

The internet has become a primary source of health information for many patients, and online patient education materials play a crucial role in providing accessible and up-to-date information about radiology procedures and safety. RadiologyInfo.org, a popular online resource for radiology education, has made significant progress in improving the readability of its content. However, a study by Bange et al. (2019) found that there are still ongoing challenges in ensuring that online radiology PEMs are accessible to a wide audience.

The study by Bange et al. (2019) evaluated the readability of online radiology PEMs using the Gunning Fog Index, a readability formula that measures the complexity of text based on sentence length and the use of complex words. The study found that the average Gunning Fog Index for online radiology PEMs was 15, indicating that the materials were written at a reading level higher than that of the general population (Bange et al., 2019). Although improvements had been made in simplifying the language and structure of the materials, the study noted that challenges remained in making the content fully accessible to all patients.

One of the key findings of the study was the need for ongoing efforts to improve the readability of online radiology PEMs. The study recommended that content creators continue to use readability assessment tools and collaborate with health communication experts to ensure that the materials are written at an appropriate reading level. Additionally, the study emphasized the importance of testing the materials with target audiences to identify areas for further improvement.

ii. *Digital Health Literacy*

In the context of online radiology education materials, digital health literacy is an increasingly important consideration. Digital health literacy refers to the ability to seek, find, understand, and use health information from electronic sources (Norman & Skinner, 2006). As more patients turn to the internet for health information, it is essential that online PEMs are not only readable but also easy to navigate and understand in a digital format.

For patients with low digital health literacy, navigating online radiology education materials can be challenging. Issues such as poor website design, complex navigation, and a lack of clear instructions can hinder patients' ability to find and understand the information they need. To address these challenges, content creators must consider both the readability of the text and the usability of the digital platform. Providing clear navigation, using visual aids, and offering interactive features can help enhance the digital health literacy of patients and improve their overall experience with online radiology education materials.

IV. Radiology Reports and Patient Comprehension

The increasing availability of radiology reports to patients through online health portals has led to a shift in how patients engage with their medical information. Access to these reports offers transparency and empowers patients to take a more active role in their healthcare. However, this access also highlights a

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significant challenge: many patients struggle to understand the technical language and complex structure of radiology reports. This section will explore the gap between patient expectations and reality, the impact of report readability on patient satisfaction, and the role of clinicians in bridging this gap.

a) Patient Expectations vs. Reality

i. Patient Access to Reports

The advent of patient portals has made it easier for patients to access their radiology reports directly, without waiting for a clinician to interpret them. While this increased access aligns with the broader goals of patient empowerment and shared decision-making, it also presents new challenges. Many patients expect that accessing their radiology reports will provide them with clear, actionable information about their health. However, the reality is often far more complex. Radiology reports are typically written in highly technical language, intended for interpretation by clinicians rather than patients.

A study by Mervak et al. (2021) found that although 80% of patients appreciated having direct access to their radiology reports, a significant portion of them reported difficulty understanding the content. This gap between expectations and reality can lead to confusion and anxiety for patients. They may misinterpret the findings, potentially assuming the worst if they cannot fully grasp the report's meaning. The study suggested that while access to reports is a step forward, the readability and accessibility of these reports need to be addressed to truly benefit patients.

ii. Study Comparisons

Several studies have compared how patients interpret radiology reports. Mervak et al. (2021) highlighted that a majority of patients experienced difficulties with medical jargon and the complex structure of the reports. In another study, Blease et al. (2020) examined the impact of direct access to radiology reports on patient comprehension. They found that while some patients valued the ability to read their reports, many struggled to extract meaningful information from them. The study emphasized that patients often misunderstood key terms or misinterpreted the severity of findings due to the technical nature of the language used.

Comparatively, studies like those by Mamlouk et al. (2020) have shown that patients who receive simplified reports or additional explanatory materials alongside their radiology results tend to have a better understanding and feel more reassured about their health. This suggests that the inclusion of patient-friendly summaries or annotations in radiology reports could bridge the gap between patient expectations and reality.

b) Impact on Patient Satisfaction

i. Understanding and Satisfaction

There is a clear link between a patient's ability to understand their radiology reports and their overall satisfaction with their care. Patients who are able to comprehend their reports are more likely to feel involved in their healthcare decisions, which enhances their sense of autonomy and satisfaction. Conversely, when patients struggle to understand their reports, it can lead to frustration, dissatisfaction, and even mistrust of the healthcare system.

A study by Ziemer et al. (2017) examined the relationship between report readability and patient satisfaction. The study found that patients who reported a better understanding of their radiology reports were significantly more satisfied with their care. Conversely, patients who had difficulty interpreting their reports were more likely to express dissatisfaction. The study concluded that improving the readability of radiology reports could have a direct impact on patient satisfaction, particularly in the context of direct patient access.

Another study by Knight et al. (2019) explored the impact of providing patient-friendly summaries along with traditional radiology reports. They found that patients who received these summaries reported higher levels of satisfaction and a greater sense of involvement in their care. The study suggested that including a brief, layperson-friendly summary of the key findings in radiology reports could be a simple yet effective way to improve patient satisfaction.

c) Role of Clinicians

i. Clinician-Patient Communication

Despite the increasing availability of radiology reports to patients, clinicians still play a crucial role in helping patients understand their medical information. The complexity of radiology reports means that many patients will still need guidance from their healthcare providers to interpret the findings accurately. Effective clinician-patient communication is therefore essential in ensuring that patients fully understand their radiology reports and can make informed decisions about their health.

Several strategies have been proposed to improve communication between clinicians and patients regarding radiology reports. One approach is for clinicians to take a more active role in reviewing the reports with patients, either during in-person consultations or through follow-up calls. This provides an opportunity for clinicians to explain the findings in simpler terms and address any concerns or questions the patient may have. Another strategy is the use of visual aids or annotated images to help patients better understand their diagnosis.

A study by Brook et al. (2018) highlighted the importance of personalized explanations. Patients who received a detailed verbal explanation of their radiology report from their clinician reported higher levels of understanding and satisfaction. The study emphasized that while patient access to reports is important, the clinician's role in contextualizing and clarifying the findings remains critical.

The role of clinicians in educating patients about their radiology reports is also supported by the work of Ganeshan et al. (2019), who argued that structured communication training for radiologists could enhance their ability to explain complex findings to patients. The study advocated for a collaborative approach, where radiologists work alongside referring physicians to ensure that patients receive clear, consistent information about their radiology results.

V. Strategies for Improvement and Future Directions

The field of radiology is crucial for patient care, yet its documentation is often perceived as complex and difficult for patients to understand. Simplifying these documents can significantly improve patient outcomes by enhancing understanding and compliance. This section explores various strategies for improvement, focusing on simplification techniques, education and training, and the role of technology.

a) Simplification Techniques

Plain Language and Visual Aids: One of the most effective strategies for enhancing the readability of radiology documentation is the use of plain language. Plain language involves writing in a straightforward and clear manner, avoiding medical jargon, and using terms that are easy for patients to understand. This approach not only makes the information accessible but also reduces anxiety and confusion, allowing patients to make informed decisions about their health.

In addition to plain language, the incorporation of visual aids can further simplify complex medical information. Visual summaries, such as diagrams, charts, and images, can help convey intricate data in a more digestible format. For instance, a visual representation of a radiological finding, like a tumor or fracture, can be easier for a patient to comprehend than a textual description alone. These visuals can illustrate the location, size, and nature of the finding, providing patients with a clearer understanding of their condition.

Interactive content, such as videos or interactive online tools, also holds promise for simplifying radiology reports. By engaging patients through interactive platforms, they can explore their radiological findings at their own pace, with options to click on specific terms for definitions or view animations that explain procedures or conditions. Such interactivity caters to various learning styles and can significantly enhance patient comprehension.

b) Education and Training

Radiologist Training: To create patient-centered radiology documents, specialized training for radiologists is essential. Traditionally, radiologists have been trained primarily to communicate with other healthcare professionals, often using technical language and complex terminology. However, to improve patient understanding, radiologists need training that emphasizes the principles of plain language and patient-centered communication. This training can be incorporated into radiology education programs, with modules focused on effective communication strategies, empathy, and cultural competence. By equipping radiologists with these skills, the quality of radiology reports can be significantly improved, making them more accessible and understandable to patients.

Interdisciplinary Collaboration: Improving the readability of radiology documentation requires a collaborative effort involving radiologists, educators, and patient advocates. Collaboration between these stakeholders can lead to the development of standardized guidelines for creating patient-friendly reports. Educators can provide insights into effective teaching methods and communication strategies, while patient advocates can offer perspectives on what patients need and expect from radiology reports. By working together, these professionals can create documents that are not only informative but also empathetic and tailored to patient needs. This interdisciplinary approach ensures that the information conveyed is accurate, understandable, and meaningful, ultimately leading to better patient engagement and health outcomes.

c) The Role of Technology

AI and NLP Tools: The advancement of technology, particularly in artificial intelligence (AI) and natural language processing (NLP), presents new opportunities for tailoring radiology reports to different audiences. AI-powered tools can analyze radiology reports and automatically simplify complex terms, generate plain-language summaries, and highlight key information relevant to patients. NLP algorithms can be designed to identify medical jargon and replace it with simpler terms or provide definitions and explanations within the text. This automated simplification process can make radiology reports more patient-friendly without compromising the accuracy or completeness of the information.

Moreover, AI and NLP tools can be customized to cater to different audiences, including both patients and healthcare providers. For instance, while patients may need simplified explanations, healthcare providers may require detailed technical information. AI can dynamically generate different versions of the same report, tailored to the needs of each audience. This customization ensures that all stakeholders receive the appropriate level of detail, improving communication and understanding across the board.

In the future, AI-driven platforms could offer real-time assistance to radiologists as they prepare reports, suggesting simplifications and enhancements based on best practices and patient feedback. Such tools could also track patient understanding and outcomes, providing valuable data to further refine and optimize the readability of radiology documentation.

VI. Discussion

Improving the readability of radiology reports is critical for patient understanding and effective healthcare delivery. This discussion provides a summary of the major findings from the review, explores the broader implications for radiology practice, and suggests future research directions to further enhance the field.

a) *Summary of Findings*

The review highlights several persistent challenges in making radiology reports more readable, even as technological advancements continue to evolve. Despite the increasing availability of digital tools and resources, many radiology reports remain difficult for patients to understand due to the use of complex medical jargon, technical language, and dense formatting. Patients often struggle to grasp the meaning of their diagnoses, prognoses, and treatment options, which can lead to confusion, anxiety, and non-compliance with recommended care.

Several key findings emerged from the review:

1. *Persistent use of Complex Language:* Radiology reports frequently use specialized medical terminology that is not easily understood by the general public. This complexity hinders patient comprehension and can create barriers to effective communication between patients and healthcare providers.
2. *Limited use of Plain Language and Visual Aids:* While there is growing recognition of the importance of plain language and visual aids, their use in radiology reports is still limited. Many reports fail to incorporate these simplification techniques, which could help patients better understand their health information.
3. *Challenges in Adapting to Patient-Centered Communication:* Radiologists have traditionally been trained to communicate with other healthcare professionals rather than with patients. This focus on professional communication has led to reports that prioritize clinical precision over patient accessibility, making it challenging for patients to fully engage with their health information.
4. *Emerging Role of Technology:* Although AI and NLP tools offer significant potential for improving the readability of radiology reports, their application is still in the early stages. The review found that these technologies have not yet been widely adopted in clinical practice, and there is a need for further development and integration to maximize their benefits.

b) *Implications for Radiology Practice*

Improving the readability of radiology reports has far-reaching implications for radiology practice, patient care, ethical considerations, and the role of technology.

1. *Enhancing Patient Care:* Readable radiology reports can improve patient outcomes by fostering better understanding and communication. When patients can easily comprehend their health information, they are more likely to engage in shared decision-making, adhere to treatment plans, and take proactive steps in managing their health. This engagement can lead to improved health outcomes and a higher quality of care.
2. *Ethical Considerations:* The ethical imperative to provide patients with understandable health information is gaining recognition in the medical community. Clear and transparent communication is essential for informed consent, which is a fundamental ethical principle in healthcare. Radiologists have a responsibility to ensure that their reports are not only accurate but also comprehensible, allowing patients to make informed decisions about their care.
3. *Role of Technology:* Technology has the potential to transform the way radiology reports are created and communicated. AI and NLP tools can automate the process of simplifying complex language, generating plain-language summaries, and customizing reports for different audiences. By leveraging these technologies, radiologists can produce reports that are tailored to the needs of both patients and healthcare providers, improving the overall effectiveness of communication.
4. *Interdisciplinary Collaboration:* To achieve meaningful improvements in report readability, collaboration between radiologists, educators, patient advocates, and technology developers is essential. By working together, these stakeholders can develop standardized guidelines and best practices for creating patient-centered radiology reports. This collaborative approach ensures that the information conveyed is not only accurate and precise but also accessible and meaningful to patients.

c) Future Research Directions

While the review provides valuable insights into the current state of radiology report readability, several areas warrant further research to continue advancing the field:

1. *Long-Term Impact of Readability Improvements on Patient Outcomes:* Future research should investigate the long-term effects of improving radiology report readability on patient outcomes. Studies could explore how readable reports influence patient understanding, compliance with treatment plans, health behaviours, and overall health outcomes. This research would provide evidence of the benefits of readable reports and reinforce the importance of patient-centered communication.
2. *Development of More Effective AI Tools:* As AI and NLP technologies continue to evolve, there is a need for research focused on developing more sophisticated and effective tools for enhancing radiology report readability. Future studies could explore how AI can be used to automatically generate multiple versions of reports tailored to different audiences, detect and replace complex medical jargon, and provide real-time feedback to radiologists during the report-writing process.
3. *Integration of Visual Aids and Interactive Content:* Further research is needed to assess the impact of visual aids and interactive content on patient comprehension and engagement. Studies could examine how different types of visuals, such as diagrams, images, and animations, affect patient understanding of radiological findings. Additionally, research could explore the potential of interactive tools that allow patients to engage with their reports, access additional information, and seek clarification on specific terms or concepts.
4. *Training and Education for Radiologists:* Investigating the effectiveness of training programs that teach radiologists how to create patient-centered reports is another important area of research. Future studies could evaluate the impact of such training on the quality of radiology reports, patient satisfaction, and communication between radiologists and patients. Research could also explore how training can be integrated into radiology education and continuing professional development programs.

VII. Conclusion

Improving the readability of radiology documentation is crucial for enhancing patient understanding, satisfaction, and overall healthcare outcomes. Clear, accessible radiology reports and Patient Education Materials (PEMs) play a vital role in fostering better communication between healthcare providers and patients. By simplifying medical language, incorporating visual aids, and utilizing emerging technologies such as AI and natural language processing, we can make radiology information more comprehensible to non-specialist audiences.

Ongoing research and interdisciplinary collaboration are essential to refining these strategies and ensuring that radiology documentation meets the needs of all patients, regardless of their health literacy levels. Radiologists, educators, and patient advocates must work together to develop standardized approaches that balance medical accuracy with readability. As efforts continue in this direction, the future of radiology documentation looks promising, with the potential to significantly improve patient-centered care and healthcare outcomes across the board.

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Table 1: Readability Formulas Commonly Used in Radiology Documentation

Formula	Description	Strengths	Limitations	References
Flesch-Kincaid Grade Level	Measures readability based on sentence length and syllable count. Originally developed for educational texts.	Widely used, simple to calculate, provides a readability grade level.	Does not consider medical jargon, context, or sentence complexity.	Flesch R. A new readability yardstick. *J Appl Psychol*. 1948;32(3):221-233. doi:10.1037/h0057532. Friedman DB, Hoffman-Goetz L. *J Cancer Educ*. 2006;21(1):2-3. doi:10.1207/s15430154jce2101_1.
SMOG Index	Focuses on the number of polysyllabic words (three or more syllables) in a text. Accurate for health materials.	Effective for health-related documents, good predictor of reading difficulty.	Complex to calculate manually, can overestimate difficulty in shorter texts.	McLaughlin GH. SMOG grading: a new readability formula. *J Read*. 1969;12(8):639-646. Doak LG, Doak CC, Meade CD. *Patient Educ Couns*. 1996;27(2):140-146. doi:10.1016/07 38-3991(95)00713-3.
Gunning Fog Index	Considers both word complexity (based on the number of complex words) and sentence length.	Useful for general readability assessment, simple calculation.	Less effective for technical and specialized texts like radiology reports.	Gunning R. *The Technique of Clear Writing*. New York: McGraw-Hill; 1952. Wang LW, Miller MJ, Schmitt MR, Wen FK. *Patient Educ Couns*. 2013;90(2):225-230. doi:10.1016/j.pec.2012.10.019.
Fry Readability Formula	Based on sentence length and the number of syllables per 100 words. Used for health literacy materials.	Simple to use, effective for shorter texts, visually represented in graphs.	Less accurate for longer, more complex documents like radiology reports.	Fry E. *J Reading*. 1977;21(3):242-252. Wang LW, Miller MJ, Schmitt MR, Wen FK. *Patient Educ Couns*. 2013;90(2):225-230. doi:10.1016/j.pec.2012.10.019.
Automated Readability Index (ARI)	Uses characters per word and words per sentence to determine readability, typically used for technical documents.	Quick to calculate, works well for technical materials.	May not accurately assess readability for all age groups, limited in health contexts.	Senter RJ, Smith EA. Automated Readability Index. Cincinnati, OH: U.S. Air Force, 1967. Kim H, Mazor KM. *J Health Commun*. 2016;21(Suppl):2-9. doi:10.1080/10810730.2016.1193910.

Coleman-Liau Index	Evaluates readability using characters per word and sentence length, emphasizing the importance of word length.	Easy to automate, effective for digital documents.	Does not consider syllable count, can misjudge medical texts.	Coleman M, Liau TL. *J Appl Psychol*. 1975;60(2):283-284. doi:10.1037/h0076540. Berland GK, Elliott MN, Morales LS, et al. *JAMA*. 2001;285(20):2612-2621. doi:10.10 01/jama.285.20.2612.

Table 2: Common Readability Scores for Radiology PEMs

Study	Type of PEM	Readability Score	Recommended Reading Level	Key Findings
Szabó et al. (2021)	General Radiology PEMs	Flesch-Kincaid Grade 12	Grade 6-8	Szabó et al. found that most radiology PEMs in Hungary are written at a high reading level, making them difficult for the average patient to comprehend. The study emphasized the need for simplified language and shorter sentences to make materials more accessible to patients with varying literacy levels.
Delaney et al. (2021)	Radiation Safety Guides	SMOG Grade 14	Grade 8-10	Delaney et al. highlighted that radiation safety materials often contain complex terminology and polysyllabic words, which significantly reduce readability. The study recommended revising these guides to include clearer language and visual aids to improve patient understanding of radiation risks.
Bange et al. (2019)	Online Radiology PEMs	Gunning Fog Index 15	Grade 6-8	Bange et al. examined online radiology PEMs and found improvements in readability over time, but challenges persist. Despite efforts to simplify content, many PEMs are still written at a high level, which limits their effectiveness for patients with lower health literacy. The study recommended ongoing revisions to online content to align with best practices for readability.
Friedman et al. (2006)	Cancer Information Materials	Flesch Reading Ease 40	Grade 6-8	Friedman et al. conducted a systematic review of cancer-related PEMs and found that many were written at a reading level too high for the average patient. The study suggested that PEMs should be routinely evaluated using readability formulas and revised to ensure they are accessible to all patients, regardless of their literacy level.
Weiss et al. (2003)	General Health Literacy Materials	Flesch-Kincaid Grade 11	Grade 6-8	Weiss et al. focused on the broader context of health literacy and patient safety, noting that many PEMs do not meet recommended reading levels. The study emphasized that improving readability is crucial for ensuring that patients understand medical information, which in turn enhances safety and health outcomes.

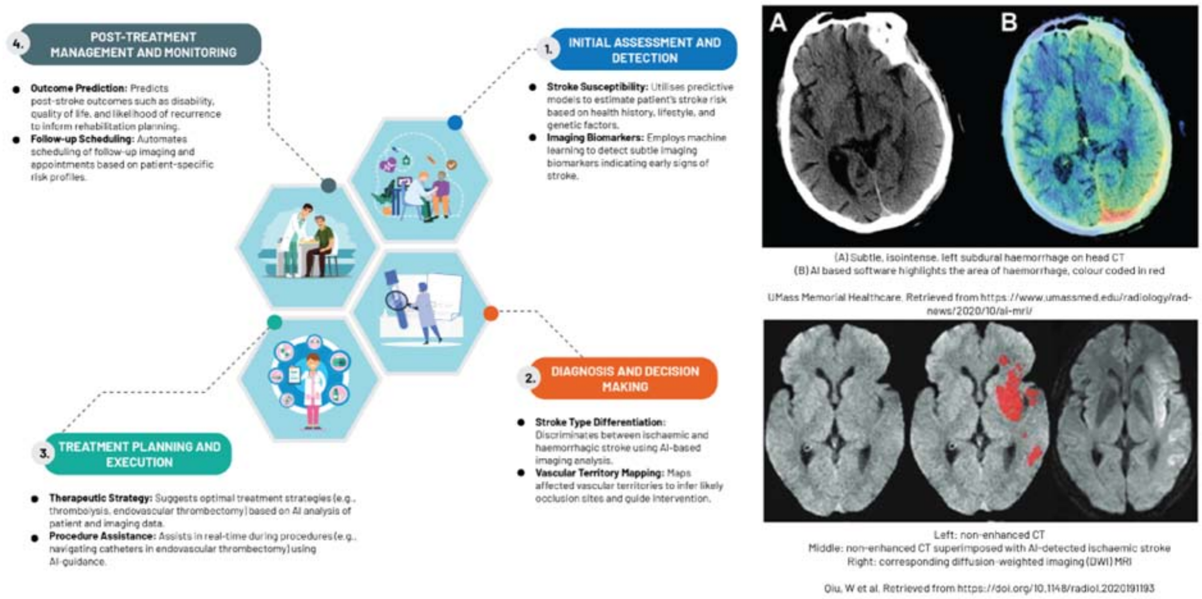

Image 1: Example of a Structured Radiology Report Before and After AI Enhancement

Caption: "Comparison of a traditional structured radiology report with an AI-enhanced version, showing improved readability for non-specialist audiences."

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Unusual Case of Large Conglomerate Mass in Abdomen

By Sajanakan Sriselvakumar

Abstract- Testicular seminoma commonly occurs in young men aged between 15 and 45 years old. Those with testicular cancer may present with a lump or swelling in the testicle. If treated and managed early, patients can expect a greater than 90% success rate. However, advanced stages of testicular seminoma can lead to eventual metastasis. We present a 45-year-old male patient with a prior history of testicular seminoma who was admitted to the emergency department with abdominal distension and mild abdominal pain. The CT identified a rather sizable abdominal mass and the biopsy report confirmed metastatic testicular seminoma. This patient is currently on active chemotherapy with bleomycin, cisplatin, and etoposide.

Keywords: metastatic testicular seminoma; abdominal pain; abdominal distention.

GJMR-D Classification: FOR Code: 1112

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Keywords: metastatic testicular seminoma; abdominal pain; abdominal distention.

I. Introduction

Testicular cancer represents 1% of male tumors and 5% of urological cancers (1) and predominantly affects young males between the ages of 15 and 45 years old (2). With early diagnosis and intervention, the prognosis is promising with greater than 90% cure rate and 95% five-year survival rate (1). There is a multitude of factors that can cause testicular cancer including cryptorchidism (2-4-fold increased risk) (3), family history of testicular cancer (6-10% fold increased risk) (4), prior history of testicular cancer (1), sexually transmitted infections (5), testicular trauma (6), and potentially elevated maternal estrogen levels (7). There may be no prominent symptomology for patients with testicular cancer (8). However, some patients may experience painless swelling and other less common symptoms such as back pain, enlargement or tenderness of breast tissue and pain in the lower abdomen (8).

Case Report

A 45-year-old man with prior medical history of testicular cancer and left orchiectomy in 2021 was admitted to the emergency room with mild abdominal pain, distention, and vomiting. Our patient reported missed outpatient attendance following their orchidectomy in 2021. He had no known testicular cancer in his family history. Additionally, there is no medical history of cryptorchidism. On initial presentation, his heart rate was 130, blood pressure was 130/70, respiratory rate of 16, oxygen saturation was 98% and he was afebrile. His tachycardia improved with fluid resuscitation. On physical examination, a large, distended abdomen and generalized abdominal tenderness was noted. His bowel sounds were present, and previous surgical scars healed well.

The abdominal and pelvic CT in *Figure 1* and *Figure 2* revealed a large undifferentiated mass localized throughout the abdomen and pelvis (transverse dimensions: 25.4 x 22.8 cm). The CT scan in *Figure 1* also demonstrated left kidney displacement and encasement of the abdominal aorta, visceral branches, and inferior vena cava. There is also encasement of the small and large bowel loops in the upper abdomen and this mass extends into the central pelvis. The liver in *Figure 2* also highlights one of the many multiple solid lesions spread throughout both hepatic lobes and is mainly right-sided. The largest solid lesions in segment 6 and 4A are respectively measuring up to 3.2 cm and 2.9 cm. Our patient proceeded to have further staging scans which did not reveal any metastatic depositions to the chest, head, and neck.

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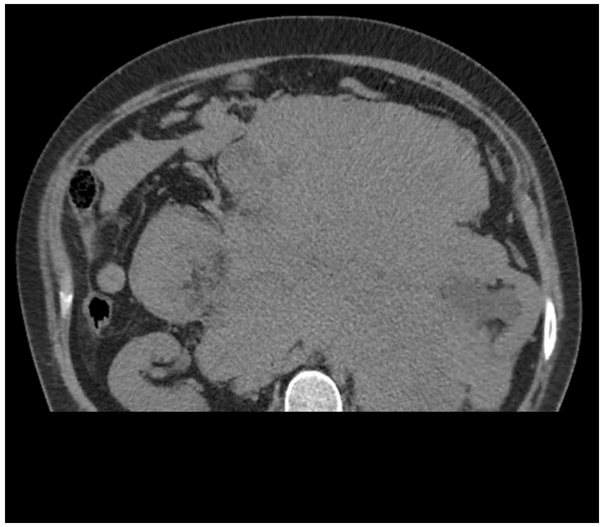

Figure 1: Axial slice of the abdomen noting large conglomerate mass located centrally with significant displacement of the left kidney and the small bowels. This mass measures up to 25.4 x 22.8cm in transverse directions

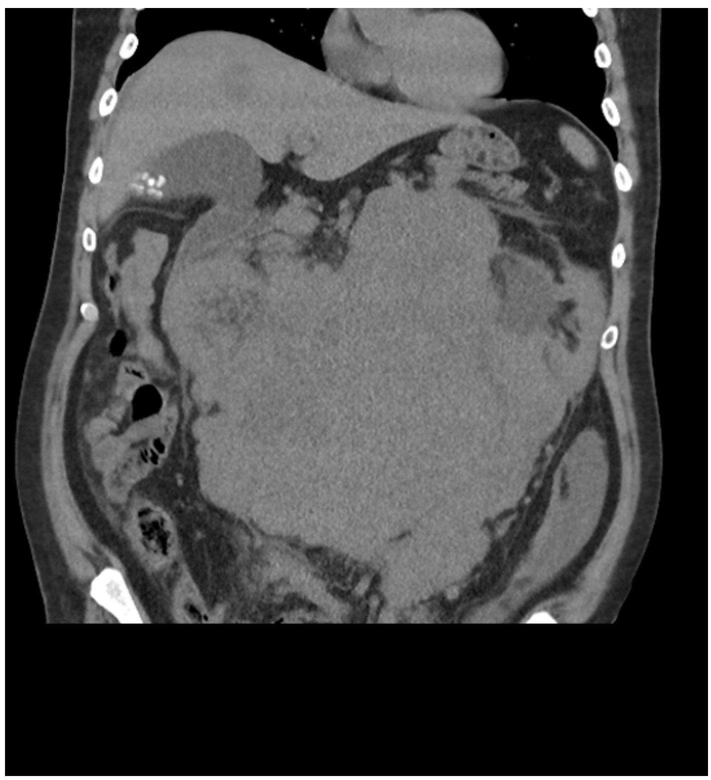

Figure 2: Coronal slice of the abdomen noting same mass with significant displacement of the bowels. A hypodense lesion can be visualised on the liver

Histopathology presented sheets of polygonal cells with substantial clear cytoplasm and vesicular nuclei, with dispersed lymphocyte-rich septa. Immunohistochemistry revealed that the tumor cells are positive for PLAP, OCT3/4 and CD117 and negative for SOX10. Hence, this histologic evaluation was deemed to be consistent with the diagnosis of metastatic seminoma for our patient.

The current oncologic diagnosis of this patient is stage IIIc seminoma. The oncologic history is pure seminoma PT1bNx with left orchiectomy in 2021. The tumor markers for this admission are alpha-fetoprotein (AFP) at 4.4, Lactate dehydrogenase (LDH) at 1230, and beta-human chorionic gonadotropin (β-hCG) at 38. He was admitted under the oncology team and started chemotherapy. He has been scheduled for 4 cycles of chemotherapy and is currently on bleomycin, etoposide, and platinum (BEP) therapy.

II. Discussion

This is a unique case of a patient presenting with abdominal distension. Abdominal distension is a common presentation to the emergency department and has a wide range of differentials (9). It is important to obtain a thorough medical history and physical examination of the patients before requesting an investigation. This patient had a left orchiectomy in 2021 and was noted to miss most of his follow-up appointments. It is important to consider imaging of these subset of patients with oncological history and has been more routinely performed in the emergency department in recent years.

Seminomas are germ cell tumors that account for up to 50% of all testicular tumors (10). These tumors metastasize within the lymphatic system with the retroperitoneal lymph nodes being the most common sites (10). The risk factors for seminomas are cryptorchidism (3), family history of testicular cancer (4), prior history of testicular cancer (1) and testicular trauma (6). This patient has a prior history of testicular cancer. His AFP was within normal levels, which is consistent with seminoma. His LDH was 1230 which is 2.5-fold above the upper normal limit for LDH.

One third of seminoma patients present with metastatic disease (10). There are different chemotherapy medications and regimens currently in use to manage this condition. This patient is currently on treatment with BEP. BEP was studied in a randomized control trial in 1980 against cisplatin, vinblastine, and bleomycin (PVB) (11). This study had a total of 244 patients, with 121 patients treated with BEP compared to 123 in PVB. 74% of patients with PVB became disease-free compared to 83% with BEP therapy. Neuromuscular toxicity was significantly less in BEP than that of PVB, favoring BEP therapy.

The results from the Internationalgerm-cell cancer collaborative group (IGCCG) compared the current data to that of original data from the 1980s for metastatic seminoma (10). The progression free survival rate (PFS) has improved from 82 to 89% with a 95% confidence interval between 87 to 90% with BEP therapy in favor of the current data. The 5-year overall survival rate in the modern series is 95% to that of 86% in the 1980s with confidence interval between 94 to 96% in patients with a good prognosis. For intermediate prognosis, the overall survival has improved from 72% to 88% with 95% confidence interval between 80-93%.

LDH has been recommended for assessment of the prognostic factor for seminoma cancer. Patients with good prognosis with LDH 2.5-fold above the normal limit had a 3-year progression free survival rate of 80% and overall survival of 92%. Patients with lower LDH level are noted to have a progression free survival rate of 92% and overall survival of 97% (10). This patient will be classed poor prognosis given the abdominal metastasis with LDH levels 2.5-fold above the normal upper limit. His current estimated 2-year survival rate is 36% with 95% confidence interval between 12-60%.

Most testicular cancers exist as a mass localized to the testicle and thereby presents as a painless testicular mass which can progress to a significant size. With early diagnosis and effective management, patients can expect to lead a good quality of life following treatment. However, this patient reported poor attendance in follow up consultations after their testicular cancer diagnosis and orchidectomy in 2021. This resulted in a significant palpable metastatic mass present in their abdominal region as the initial manifestation from testicular seminoma confirmed via CT scan and histological assessment. This patient is currently on bleomycin, etoposide, and platinum (BEP) therapy and is scheduled for four cycles of chemotherapy.

III. Conclusion

Testicular seminoma is a common malignancy amongst young men between the ages of 15 and 45 years old (2). Most patients will not experience obvious symptoms. However, there may be a subset of patients experiencing less common symptomatology such as abdominal and back pain. Perhaps young men experiencing regular, painful bouts of abdominal pain should also be considered for testicular cancer especially if the patient has a history of testicular malignancy.

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Conflict of Interest

The authors declare no conflict of interest in preparing this article.

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Neuronavigation Assistance. Decreased Radiation Exposure During Spinal Surgery in Patients with Severe Combined Trauma

By R.V. Yarmoshuk & M.I. Spitsyn

Summary- The results of studies of intraoperative x-ray radiation with the participation of two groups are presented: the main database using a neuronavigation group and a control group where standard 2D fluoroscopy was used. The radiation load on the operating surgery and operating supporting staff was estimated. Stryker iNtellect ENT Second Generation Navigation for the Injured of RFD Ziehm Vision Core and Optical Converters for the Injured of the Control Group. Variants of visualization using an electron-optical transducer are especially important for minimally invasive procedure where instrumentation is performed percutaneously without direct anatomical control in contrast to open procedures or work with misrepresented anatomical structures in case of injuries. Biplanar fluoroscopy was one of the first methods of intraoperative imaging in real time as well as one of the most advanced technologies in orthopedic and spinal surgery. However, radiation exposure from intraoperative fluoroscopy remains a serious problem for patients, surgeons and supporting staff.

Keywords: *intraoperative radiation, neuronavigation, biplanar X-ray electron-optical transducer, individual dosimeter, detector, transpedicular fixation, fluoroscopy, ionizing radiation.*

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R.V. Yarmoshuk [α] & M.I. Spitsyn [σ]

Summary- The results of studies of intraoperative x-ray radiation with the participation of two groups are presented: the main database using a neuronavigation group and a control group where standard 2D fluoroscopy was used. The radiation load on the operating surgery and operating supporting staff was estimated. Stryker iNtellect ENT Second Generation Navigation for the Injured of RFD Ziehm Vision Core and Optical Converters for the Injured of the Control Group. Variants of visualization using an electron-optical transducer are especially important for minimally invasive procedure where instrumentation is performed percutaneously without direct anatomical control in contrast to open procedures or work with misrepresented anatomical structures in case of injuries. Biplanar fluoroscopy was one of the first methods of intraoperative imaging in real time as well as one of the most advanced technologies in orthopedic and spinal surgery. However, radiation exposure from intraoperative fluoroscopy remains a serious problem for patients, surgeons and supporting staff. The negative effects of ionizing radiation lead to cell damage through the induction of deoxyribonucleic acid (DNA) and the release of reactive oxygen species. In this regard, cell death or genome instability occurs which leads to various radiation-related pathologies. It was found that the use of neuronavigation programs can reduce the number of errors, reduce intraoperative trauma and significantly reduce the intraoperative radiation load on the injured, operating surgical and operating supporting staff. The large-scale introduction of navigation technologies will reduce or eliminate the harmful effects of ionizing radiation on the injured and medical personnel.

Keywords: intraoperative radiation, neuronavigation, biplanar X-ray electron-optical transducer, individual dosimeter, detector, transpedicular fixation, fluoroscopy, ionizing radiation.

I. Introduction

Currently, much attention is being paid to the impact of ionizing radiation on patients and medical personnel. This is due to the fact that in almost all fields of medicine, diagnostic search and surgical imaging techniques are closely related to x-ray radiation.

One of the most important diagnostic methods of mankind appeared due to Professor of Physics at the University of Würzburg Wilhelm Conrad Roentgen (1845-1923), who discovered the "X-rays" on November 8, 1895, for which he was later awarded the Nobel prize. It was the time when the era of medical imaging begins, which allows us to objectively assess the quantitative and qualitative pathological processes occurring in the human body.

One of the urgent problems of minimally invasive surgery is the impact of ionizing radiation on the human body, particularly the effect on the structure of deoxyribonucleic acid (DNA), which leads to irreversible changes. Negative effects of ionizing radiation lead to cell damage through DNA induction and the release of reactive oxygen species. In this regard, cell death or genome instability occurs, which leads to various radiation-related pathologies. Children and people of reproductive age are primarily at high risk [1, 2]. This is due to the high intensity of replication processes which occur with damage to the DNA structure under the influence of ionizing radiation, thereby causing mutations in the daughter chain. The probability of transmitting a damaged DNA chain to offspring is currently not confirmed [3].

The most frequent and actively used type of imaging when fixing the spine with transpedicular metal structures is biplane radioscopy.

In the attempts to reduce the risks associated with ionizing radiation to the body, radiation safety has become an important topic in the medical industry. All practitioners regardless of the field of medicine can apply the radiation safety methods, including shielding and distancing to reduce radiation exposure. In addition, detailed adjustment of the parameters for bringing doses of fluoroscopic racks and new imaging techniques can be used as an effective way to reduce the radiation dose [9].

Neuronavigation systems have become a new visualization technique. The main purpose of these systems was to provide a reliable assistance for surgical interventions, to reduce intraoperative radiation load and surgical aggression [4]. While the number of new advanced radiation safety technologies in spinal surgery is not large, much needs to be done to overcome the difficulties and limitations associated with funding, material supply, and a fairly labor-intensive training process.

The use of fixation structures and other implants is particularly relevant in the field of spinal surgery, where instrumentation is often used for the treatment of degenerative, traumatic and neoplastic diseases.

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Screws used for spinal fusion are the most widely used methods of stabilization in spinal surgery, but inaccurate implantation of such structures can lead to significant intraoperative and postoperative complications [6, 11, 13]. In particular, damage to nearby neurovascular structures can occur leading to severe complications or disability of patients.

To ensure high accuracy of placement of metal structures in spinal surgery intraoperative radiography is used as a navigator when placing implants [12, 16]. This imaging option is particularly important in minimally invasive interventions where instrumentation is performed percutaneously without direct anatomical imaging as opposed to open procedures or surgery of misrepresented anatomy in case of injuries.

2D fluoroscopy is the first and one of the most reliable methods of intraoperative navigation in real time and continues to be one of the leading techniques for controlling screw implantation [5, 8, 10].

However, radiation exposure from intraoperative fluoroscopy is a serious problem for patients, surgeons, and operating room support staff [14 – 15, 17 – 18]. Personal protective equipment and the latest imaging techniques such as neuronavigation have been developed in order to reduce the risk associated with intraoperative radiation. Organizations have also been established in our country and abroad that have developed documents and legal acts regulating work with ionizing radiation designed to protect staff and patients from the harmful effects of radiation. In our country the documents regulating work with x-ray radiation are the sanitary rules and regulations "Hygienic requirements for the device and operation of x-ray devices and x-ray research" SanPiN 2.6.1.1192-03, Federal law No. 3 of 09.01.1996 "About radiation safety of the population", Order of the Minister of Defense (MD) of the Russian Federation (RF) of 07.04.2003 No. 111 "Approval of instructions for the organization in military units and institutions using sources of ionizing radiation".

The criteria of these guidelines are designed to protect those who are exposed to excessive radiation exposure in professional practice as well as to reduce the radiation load on the patient. The main international organization developing these guidelines is the International Commission on Radiological Protection (ICRP).

In both national and foreign regulatory documents, the dosage limits are expressed in joules per kilogram (j/kg) otherwise known as Sievert (SV). The latter is a measure of stochastic exposure of ionizing radiation and an exposure of 1 SV is associated with a 5.5% risk of cancer. According to the ICRP guidelines occupational exposure should be limited to a maximum average of 20 mSv per year for no more than a five-year period, with exposure not exceeding 50 mSv per year. Exposures should be strictly limited to a maximum average of 1 mSv per year over a 5-year period for patients [7]. These values can be used as benchmarks for evaluating the safety and effectiveness of new imaging technologies and anti-radiation protection methods. At the same time, when there is a question of saving the life of the injured the standards and doses of ionizing radiation affecting the injured are erased or expanded.

II. Purpose of Research

To prove experimentally that neuronavigation technologies in comparison with standard methods of fluoroscopy can significantly reduce the intraoperative radiation load on the injured, surgeons and auxiliary medical personnel of the operating room.

III. Materials and Methods

The results of 21 patients with combined vertebral-cerebrospinal injury (VCI) who made up the main hard data were analyzed prospectively as well as the results of treatment of 45 patients with severe combined injury (SCI) of spine and spinal cord who made up the control group.

The average age of the injured of the main hard data was 39 years, including 18 men and 3 women. The average value of the severity of combined trauma on the scale of military field surgery-injuries (MFS-I) = 5.8 points.

The injured of this group were operated on for spinal injuries in the clinic of Military Field Surgery (MFS) of the Military Medical Academy named after S. M. Kirov (MMA) in the period from 2017 to 2019. The injured were included in the main hard data according to the following criteria: all of them had combined injuries to the spine and spinal cord, indications for performing posterior spondylodesis based on data obtained by computed tomography (CT) and/or magnetic resonance imaging (MRI), performed when they were hospitalized in the clinic's reception and diagnostic Department (RDD). The use of CT-based intraoperative neuronavigation for spinal surgery has been studied to reduce the use of radioscopy and improve the accuracy of screw implantation.

The average age of the injured of the control group was 33 years, including 35 men and 10 women. The average value of the severity of combined injuries on a scale MFS-Iwas 8.8 points. The injured were operated on at the MFS of MMA clinic between 2011 and 2016.

The injured of both groups had similar spinal injuries (compression-comminuted fractures, fractures-dislocations, spondylolistheses) accompanied by instability and neurological deficit. The spinal operations were performed using standard fluoroscopy.

In the control group, the screws were implanted using classical fluoroscopy using a Vision RFD device manufactured by Ziehm (Germany). Individual

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dosimeters (ID) were used to assess radiation exposure from intraoperative fluoroscopy. In the course of the study the radiation dose received by the injured, operating surgeons and other medical personnel of the operating room (anesthesiologists, anesthesiologist and operating nurses, aidmen) was evaluated.

Note that radiation exposure during spinal surgery is a serious risk factor for operating surgeons, staff and patients adversely affecting the body. However, the actual biological effect is determined by cumulative exposure over long periods of time. The cumulative effect of x-rays can be a serious risk to the health of surgeons and medical staff. The radiation dose that affects the body will be affected by the factors such as the distance from the source to the object, screening and the time of the x-ray. The main tasks facing medicine to reduce the impact of ionizing radiation on surgeons and medical personnel are to find ways to reduce radiation load.

To evaluate the received doses of ionizing radiation of surgeons during surgery, the ID was placed on the surgeon:

1) in the orbits and under the surgical magnifying glass, in maximum proximity to the eye (fixed on the bracket), figure 1;

Figure 1: Individual dosimeter fixed in the orbit area

2) In the area of the neck that is not covered by the neck collar (the neck of surgical underwear is fixed) to assess the impact on the thyroid and upper breast (Fig. 2);

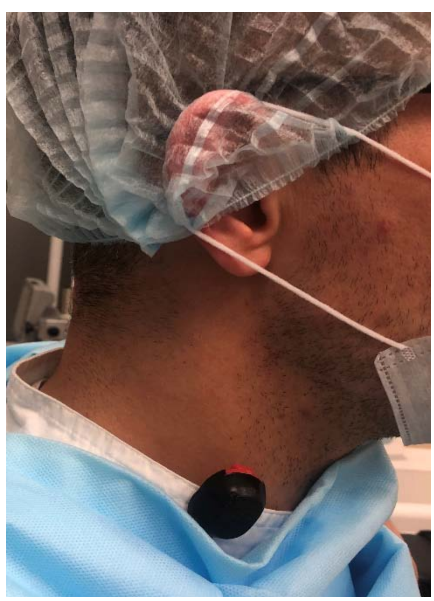

Figure 2: Individual dosimeter fixed in the neck area

3) On the right back surface of the operating surgeon's right hand, in the area of the wrist joint under the surgical glove (Fig. 3);

Figure 3: Individual dosimeter fixed in the area of the wrist joint

4) On the surface of the chest and in the groin area under the standard protective apron of the surgeon (Fig.4).

Figure 4: Standard x-ray protection apron

All personal protective equipment is regulated by the interstate standard from 01.01.2015 "Protection Against X-ray Radiation in Medical Diagnostics. Part 3. Protective Clothing", individual dosimeters on the injured were located in the scanning zone (cervical, thoracic, lumbar spine). Tracking the doses of ionizing radiation on the injured for each zone was performed using two IDs to clarify the average value. In the operating room two sensors were placed which were located from the x-ray source at a distance of 1 and 2 m. In addition, we used individual thermoluminescent dosimeters (thermoluminescent solid-state detector TSD-4 TU 50.477-85) of the company "DTU-1". After the surgery the dosimeters were removed from the work area and protected from further radiation.

All the IDs used in our study were identical and the results from all the sensors were recorded on the same device by the same specialist who was responsible for the measurement results. The dosimeters were processed and the measurements were tabulated.

The x-ray source of the electron-optical Converter (EOC) was located in 2 projections (straight and side) in relation to the operating field and on the side opposite to the surgeon (Fig. 5). The injured was not screened in the operating room.

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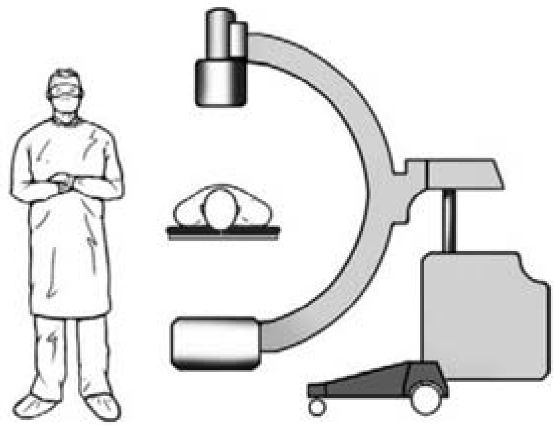

Figure 5: The position of the EOC x-ray source in relation to the patient's back

For the injured of the main hard data the 2nd-generation "iNtellect Navigation" of Stryker (USA) was used to install the transpedicular structure (Fig. 6).

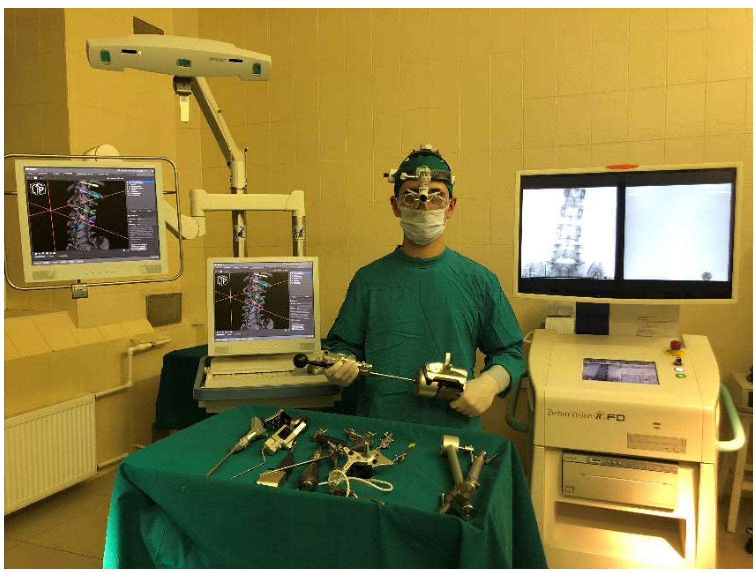

Figure 6: Neuro-navigation rack "iNtellect Navigation" of company "Stryker" (USA) with a set of basic tools

All the injured were operated on using 3D modeling of data obtained during preoperative CT scanning.

Single "forced radiation doses" for diagnostic and therapeutic purposes the so-called average effective doses per examination using medical sources of ionizing radiation were as follows:

- Radiography overview (chest) - 0.150-0.400 mSv;
- Radiography of the limb-0.02 mSv;
- Computed tomography on standard devices – 20 mSv, if the study was performed in the "Whole body" mode and is a native scan-40 mSv. In cases where contrast is introduced during the study – 50 mSv for one study in the "Whole body" mode (the figures may vary depending on body weight, injuries, etc.).

At the same time, the maximum allowable annual rate for personnel working with x - ray radiation is 20 mSv (the periods of receiving this dose should not exceed 5 years); the maximum annual rate for a healthy person is 1 mSv; natural annual radiation for a person is 3 mSv per year; the first signs of radiation sickness are 250 - 300 mSv.

IV. Results and Discussion

It was found that the dose of x-ray radiation during the installation of transpedicular fixation using x-rays on the cervical, thoracic and lumbar spine with a total number for the entire structure was: for the injured in the lumbar spine and pelvic region – 1.22 mSv-1st detector; 1.05 mSv-2nd detector, average value-1.14 mSv (0.11 P), for the thoracic spine and chest cavity organs – 1st detector-2.17 mSv, 2nd detector – 2.0 mSv, average value-2.09 mSv (0.2 P), and the cervical spine – 1st detector – 0.264 mSv, 2nd detector – 0.212 mSv, average value-0.238 mSv (0.023 P).

For the operating surgeon the x – ray radiation dose when fixed on the right hand was-1st Indicator

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detector – 1.87 mSv, 2nd detector-0.75 mSv, average value – 1.31 mSv (0.26 p), on the protected thyroid gland– 1st detector – 0.12 mSv, 2nd detector-0.095 mSv, average value – 0.11 mSv, on the head and eye area-1st detector – 0.09 mSv, 2nd detector – 0.07 mSv, average value – 0.08 mSv (0.009 p). In turn, personal protective equipment against x-ray radiation (individual aprons) demonstrated a reliable protection since the radiation dose on dosimeters when working with them was – 0 mSv.

X-ray irradiation doses when installing transpedicular fixations at different levels of the spine on a single screw were as follows: in the cervical spine – 0.034 mSv, in the thoracic spine – 0.075 mSv and in the lumbosacral spine-0.063 mSv.

Indicators of ID located in the operating room at a distance of 1 and 2 m from the x-ray source were 0.3 and 0 mSv (Fig. 7). This location of the ID was necessary to assess the spread of x-rays in the operating room.

Figure 7: Scheme of x-ray radiation spreading in the operating room

This drawing shows the top view of the EOC in the position above the patient. Dosimeters were placed within a radius of 1 and 2 m from the center of the EOC x-ray source. In this case the radiation exposure varies not only with the distance (the lowest radiation dose beyond 2 m), but also with the angle of the x-ray source position in the EOC. Thus, the spreading of rays in a vertical plane is practically absent, but when the source is changed to a horizontal position the rays spread over a distance of 1 m. All radiation dose data obtained in our study are shown in table 2.

Table 2: Table of radiation doses received during the study, mSv

<table>
<tr><th>Indicator</th><th colspan="5">Spine Department</th></tr>
<tr><td>Methods of visualization</td><td colspan="2">cervical spine</td><td colspan="2">thoracic spine</td><td>lumbar spine</td></tr>
<tr><td>Radiography
(per screw)</td><td colspan="2">0,034</td><td colspan="2">0,075</td><td>0,063</td></tr>
<tr><td>Total radiation dose (by parts for the entire operation)</td><td colspan="2">0,238</td><td colspan="2">2,09</td><td>1,14</td></tr>
<tr><td colspan="6">The area of exposure of the surgeon</td></tr>
<tr><td>Methods</td><td>eye socket</td><td>Neck</td><td>Right arm</td><td>Chest</td><td>Pelvis</td></tr>
<tr><td>Radiography</td><td>0,08</td><td>0,11</td><td>1,31</td><td>0</td><td>0</td></tr>
<tr><td>Navigation</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">Operating room</td></tr>
<tr><td>Distance from the x-ray source (during the entire operation), m</td><td colspan="2">1</td><td colspan="3">2</td></tr>
<tr><td>Radiation dose</td><td colspan="2">0,3</td><td colspan="3">0</td></tr>
</table>

Thus, the average dose of ionizing radiation received by the injured of both groups in the course of treatment and performing forced x-ray diagnostics was from 40.3 to 74.6 mSv (exceeded the annual radiation exposure for a healthy person by 40 times). Thanks to the use of neuronavigation technologies for spinal operations intraoperative radiation was reduced by 14 times since they performed only 2 control images to clarify the positioning of screws in the vertebral bodies which was 0.15 mSv. Medical personnel in the operating room were not exposed to ionizing radiation at all. Patients of the control group depending on the damaged spine were intraoperatively subjected to additional x-ray irradiation at a dose of 1.15 to 2.1 mSv which is associated with the use of EOC for navigation.

Exposing patients to excessive radiation the doctor of each specialty should understand that it is possible in the long term this radiation may affect the development of neoplastic processes in patients and medical personnel.

Specialists performing surgical interventions using x-ray navigation must use personal protective equipment (aprons and collars) approved by regulatory documents. But despite the measures taken for screening, the surgeon's body remains unprotected places that are exposed to x-ray radiation. For example, the total dose that a surgeon receives for the distal area of the upper limb on average for one operation on the spine or extremities is 1.31 mSv, and for the eye area (depending on the position of the surgeon from the EOP) – 0.08 mSv. Having performed about 15 similar operations, the surgeon already significantly exceeds the professional average annual radiation dose established by regulatory documents. At the same time performing surgical interventions using neuronavigation the surgeon receives a minimal x-ray radiation which in some cases is reduced to zero.

In general, in our opinion in terms of the effectiveness, intraoperative radiation safety and ease of use navigation technologies as a means of intraoperative visualization are the most preferable in comparison with standard methods of radioscopy. At the same time the entire medical staff of the operating room can continuously assist in the process of surgery without being exposed to radiation. The operating room increases the working space associated with bulky equipment and wires. One of the important aspects of its application of navigation technologies for intraoperative visualization is the absence of harmful ionizing effects on the operating surgeon.

V. Conclusions

1. Neuronavigation technologies can significantly reduce the radiation load on the injured, reduce the ionizing effect on surgeons and operating room support staff to almost zero.
2. When using neuronavigation the surgeon has more opportunities to move around the operating table since there are no bulky devices in the form of an ionizing radiation source and an EOC receiving panel that restrict these actions.
3. Due to the absence of constant ionizing radiation in the operating room, all its medical personnel (anesthesiologists, nurses,aidmen) can perform their professional duties during surgery without fear of radiation exposure.

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6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- o Explain the value (significance) of the study.
- o Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- o Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- o Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- o Report the method and not the particulars of each process that engaged the same methodology.
- o Describe the method entirely.
- o To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- o Simplify—detail how procedures were completed, not how they were performed on a particular day.
- o If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- o Resources and methods are not a set of information.
- o Skip all descriptive information and surroundings—save it for the argument.
- o Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

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Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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