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Web-based Prostate Visualization Tool

<https://doi.org/10.1515/cdbme-2020-3144>

Abstract: Proper treatment of prostate cancer is essential to increase the survival chance. In this sense, numerous studies show how important the communication between all stakeholders in the clinic is. This communication is difficult because of the lack of conventions while referring to the location where a biopsy for diagnosis was taken. This becomes even more challenging taking into account that experts of different fields work on the data and have different requirements. In this paper a web-based communication tool is proposed that incorporates a visualization of the prostate divided into 27 segments according to the PI-RADS protocol. The tool provides 2 working modes that consider the requirements of radiologist and pathologist while keeping it consistent. The tool comprises all relevant information given by pathologists and radiologists, such as, severity grades of the disease or tumor length. Everything is visualized using a colour code for better understanding.

Keywords: Web-based applications, prostate, visualization, communication in the clinic

1 Introduction

Prostate cancer is the fifth leading causes of cancer deaths worldwide [8]. An early diagnosis and a proper treatment are needed to improve cancer survival. This does not necessarily consist of an invasive surgery. Conservative treatments are often equally effective and have less side-effects [4]. To facilitate the diagnosis and treatment decision there are two aspects that are highly important: the doctor-patient communication and a correct communication between all stakeholders in the clinic, the latter being the focus of this paper.

In the clinic numerous stakeholders are involved in the diagnosis. Usually, urologists carry out a biopsy and send the tissue samples to pathologists. Pathologists analyse the sample and write a report based on these analyses. Alternatively, they insert the findings in a database. The pathologists describe the area of the prostate where the corresponding punch was in-

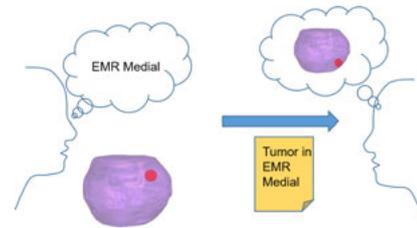


Fig. 1: Failed communication between different stakeholders in the clinic. One expert uses a particular naming (EMR Medial) to describe the position of the tumour in the prostate. A colleague receives the report written by the first expert and misinterprets the referred position.

serted. Unfortunately, many pathologists use their own naming for these purposes. Radiologists, on the other side, work with magnetic resonance (MR) images and directly mark there the location of interest. Inconsistencies with respect to the prostate nomenclature [5] makes the communication even harder as doctors often have a personal way to refer to different areas.

Several tools have been proposed so far to facilitate the prostate cancer diagnosis and treatment decision. Most of them however, focus on the first aforementioned aspect, namely the patient-doctor communication. Franklin et al. [3] propose an interactive method for risk communication. Hakone et al. [4] propose a tool to show the patients the advantages of conservative treatments over surgery using charts and statistics. Alexander et al. [1] propose an interactive single cell genomics viewer to visualize the evolution of prostatic neoplasia. Bernard et al. [2] propose a novel technique to visualize the patient's history. For this they use charts and dashboards. The method incorporates the possibility to analyse patient cohorts. All these methods represent their results mainly with bar charts.

In this paper a web-based prostate communication tool (WPCT) is proposed that uses the PI-RADS (Prostate Imaging Reporting and Data System) protocol [6] to facilitate the consistent naming of the areas in the prostate. This protocol was designed by the American College of Radiology, the AdMeTech Foundation and the European Society of Urogenital Radiology with that purpose in mind. The proposed visualization does not only incorporate bar charts but also a model of the prostate divided into different segments that are coloured according the information they comprise. The proposed tool has been developed following the requirements of clinicians. Thus, all visualizations and used grading systems reflect their direct needs.

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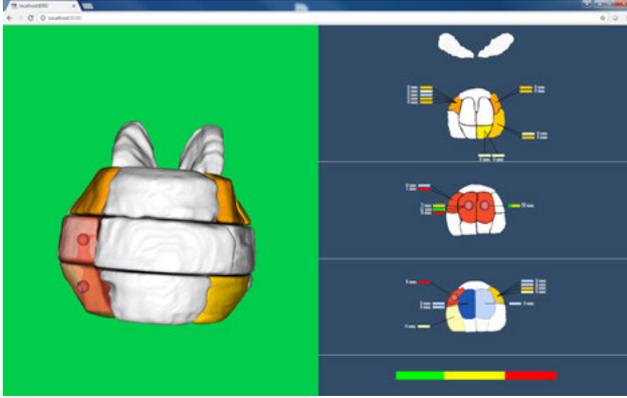


Fig. 2: General overview of the web-based tool. Pathologists mode.

2 Methods

As mentioned before the idea of this work is to facilitate the communication between different clinical experts. Figure 1 illustrates the existing challenges. Each clinical expert describes with a different wording the location of the punch. Thus, when a new expert works with this information he does not know exactly to which area of the prostate the previous one refers. This becomes even more complicated when working with information that was saved long time ago or even for inter-clinic communication. Thus, the radiologists and pathologists cannot know exactly where the punch belongs to.

In the proposed WPCT pathologists and radiologists can consistently add all relevant findings and automatically save this information in the database of the clinic. The visualization can be loaded again anytime and edited accordingly. Figure 2 shows the general appearance of the tool when a patient has been selected. On the right side the prostate base, mid and apex views are visualized. The seminal vesicle is also shown for orientation purposes. A 3D visualization of the prostate on the left side completes view.

The severity of the findings for each biopsy punch can be graded as: Healthy tissue, Prostatic Intraepithelial Neoplasia, Atypical Gland Tubes or Tumour. Both Prostatic Intraepithelial Neoplasia and Atypical Gland Tubes are precancerous conditions. After a biopsy has taken place the pathologist analyses the extracted tissue sample in order to determine how aggressive the tumour is (prostate cancer staging). The Gleason grading system is often used for these purposes. Each one of its 5 grades determines one cell pattern. Gleason grade 1 represents nearly normal cells. Grade 5 cells on the contrary show high severe tumours. Grades 3 to 5 are specially relevant for the diagnosis. Unfortunately, the conventional Gleason grading system does not consider the also relevant information related to tertiary Gleason patterns. Thus, Sauter et al.

Fig. 3: Control panel that serves to add all information relevant to a punch.

[7] propose the concept of Gleason IQ that combines the Gleason grading and tertiary Gleason grades. This novel concept is given by

$$GleasonIQ = \begin{cases} G4 + G5 + 10 & \text{if } G5 > 0 \\ G4 + G5 + 7.5 & \text{if } G5 > 20 \end{cases} \quad (1)$$

where $G4$ and $G5$ are Gleason 4 and Gleason 5 respectively. The information included for each punch should contain the severity grade of the finding. Furthermore, when a punch indicates the presence of a tumour additional information has to be included, namely, the length of the tumour and the corresponding Gleason 3%, 4 % and 5% (in a single sample more than one pattern can be found) and Gleason IQ.

As mentioned before, different stakeholders use different ways to describe the finding. The web-based tool proposed in this paper consists on two modes so that all clinical experts can work as close as possible to the way they are used to, but at the same time the consistency is kept.

2.1 Mode 1: Pathologists

Pathologists usually describe with words in a report or database the location of the punch. Unfortunately, each one uses his own convention to do this, for example, EMR medial, P-Zone left or Extra Middle Right Lateral. This results in a situation in which the actual location of the punch is difficult to reproduce when a new expert works on that data.

We propose to use the PI-RADS protocol to make this description consistent and easy to understand by all stakeholders. In order to accomplish this we created a model of a prostate and we divided it into the 27 segments that compose the PI-RADS protocol. After a pathologists has analysed a concrete sample, he can add the information related to that punch by simply inserting a new punch into the appropriate segment. Previously, the pathologists should add the information that

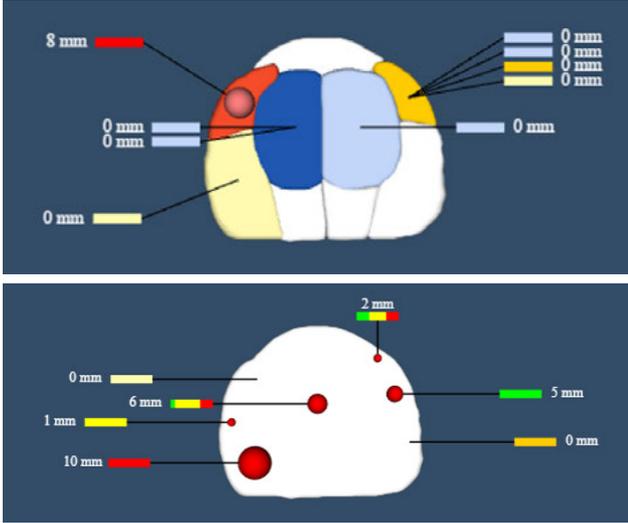


Fig. 4: Top: Apex 2D view of the prostate model with several inserted punches. PI-RADS segments are used to divide the prostate in different areas. Bottom: Apex 2D view of the prostate model with several inserted punches. In mode 2 PI-RADS segments are not visualized.

corresponds to this punch using a control panel (See Figure 3).

As soon as the punch is inserted the visualization is updated. Each punch will be visualized as a bar that is connected to the appropriate segment (see Figure 4 top). Furthermore, the length of the tumour is visualized next to its corresponding bar.

A colour code is used to incorporate the findings in the visualization (see Table 1). The colour of the bar will change depending on the severity of the finding. Furthermore, the background colour of the corresponding segment will also vary depending on the illness level. When more than one punch is assigned to that concrete segment, the background colour will correspond to the punch with the most severe findings. For example, if segment 1a has a punch that indicates *atypical gland tubes* and a second one that indicates *prostatic intraepithelial neoplasia*, the colour corresponding to the former will be used for the visualization. If multiple punches with the same severity level exist the segment background will acquire a darker tone.

The 3D view will also update accordingly. Segments will be visualized semitransparent with the colour corresponding to the appropriate illness level. When the punch indicates that there is a tumour in certain segment a sphere with a radius proportional to the tumour length will be visualized both in 2D and 3D.

There is an additional bar below the three 2D views of the prostate that represents the average Gleason 3%, 4% and 5% of all punches. This bar will be updated every time a new punch

Used for	Meaning	Colour	Hex Colour
Punches	Healthy		#C2D6FA
Punches	PIN		#FFFAB0
Punches	AGT		#FFCC00
Punches	Gleason 3		#00FF00
Punches	Gleason 4		#FFFF00
Punches	Gleason 5		#FF0000
Segments	No punch		#FFFFFF
Segments	Single Healthy Punch		#C2D6FA
Segments	Multiple Healthy Punch		#1F57B0
Segments	Single PIN Punch		#FFFAB0
Segments	Multiple PIN Punch		#FFF000
Segments	Single AGT Punch		#FFCC00
Segments	Multiple AGT Punch		#FFA100
Segments	Tumour(s)		#F54D2B

Tab. 1: Colour code used to represent each information. Punches and Segments refer to the area that will be coloured, namely, the punch bar and the segment background respectively. PIN: Prostatic Intraepithelial Neoplasia. AGT: Atypical gland tubes

is inserted. Let $i \in [3, 4, 5]$ then the average of a Gleason grade i over all punches is given by:

$$G_i = \frac{\sum_{p \in P} p_l * p_{G_i}}{\sum_{p \in P} p_l}, \quad (2)$$

where P is a set containing all punches inserted so far. p_{G_i} is the Gleason i value of the current punch p . Since the findings at each punch are not equally severe, p_{G_i} is weighted with the tumour length p_l detected at p . The obtained value is normalized over the complete tumour length.

Editing information of a certain patient is also possible. When information about a certain punch needs to be updated, the pathologist can simply select the appropriate punch and make the necessary changes using the control panel. At any moment, the new information can be sent to the server where the database will be updated with the new patient information. Thanks to the naming convention patient information can be loaded at any moment to edit or study it. Any stakeholder can work on that data immediately without the need of further explanation. In addition, various stakeholders can then easily discuss about a certain patient and they will immediately know which punch they refer to.

2.2 Mode 2: Radiologists

Radiologists do not work with the samples extracted with a biopsy. Instead they analyse the MR data and directly mark the position of the punch on them. This means that they do not work with segments, neither they describe the position with specific words as the pathologists do. So that they can still feel

comfortable using the web-based tool we incorporated a visualization that does not show any segments. The radiologists can then insert punches by simply adding any relevant information using the previous control panel and clicking on the correct position in one of the 2D views (see Figure 4 bottom). As in mode 1 punches can be updated by just selecting the corresponding punch and changing its information in the control panel.

3 Discussion and future work

The tool has been designed and developed following the needs and requirements of our medical partners who after each step gave constructive feedback to improve the tool. This way the development process became an iterative one, starting from a simple mockup to finally arrive to the current tool, in which all requirements are incorporated. As such, the tool is expected to be relevant during the clinical practice. However, only a series of initial tests have been carried out so far as a proof-of-concept. A thoroughful evaluation in the working environment of the clinical users is further needed and will be addressed in the future.

Another important aspect that will be studied in the future is the extension of this tool to its use for the doctor-patient communication. As shown in the introduction the tools that focus on this aspect base their visualization on statistics and represent their results mainly with bar charts. At the moment when patients are informed about having a tumour, however, they feel blocked and unable to completely understand the information hidden in such representations (see Figure 5) [4]. Instead of using plain text or statistics, the medical doctor could use the web-based tool in the communication with the patients. Therefore, he would just need to select the corresponding patient and all his information would be automatically loaded from the server and visualized. The visualization that is proposed in this paper could help the patients understand the most relevant information regarding their diagnosis. This information could be then combined with a treatment communication system like those proposed in the state of the art to further inform the patient about possible solutions to his illness. However, in order to use the tool for these purposes further research is needed. The requirements of the medical doctors in this respect were already included in the proposed tool (as expressed by the clinical partners during the development of the tool). Nevertheless, feedback from the patients is equally important for this communication and their needs should be incorporated in the current tool for it to be useful during doctor-patient communication.

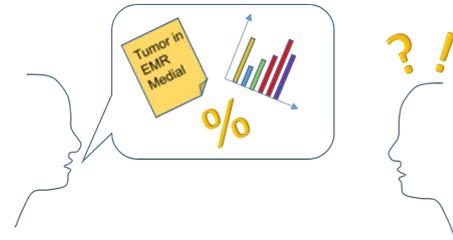


Fig. 5: The communication with the patient with the simple use of reports and graphs does only increase the anxiety and confusion of the patient.

4 Conclusion

The communication in the clinic is difficult because of the lack of conventions while referring to the location where a biopsy was acquired. In this paper a WPCT is proposed that incorporates a model of the prostate and visualizes all punches and tumours. A colour code is used to increase the direct visual understanding of the current health status. The segments of the PI-RADS protocol are also shown to improve communication between current and future stakeholders.

Author Statement

Research funding: The author state no funding involved. Conflict of interest: Authors state no conflict of interest.

References

- [1] J. Alexander et al. "Utility of Single-Cell Genomics in Diagnostic Evaluation of Prostate Cancer." In: *Cancer Res.* 78.2 (2017).
- [2] J. Bernard et al. "Using Dashboard Networks to Visualize Multiple Patient Histories: A Design Study on Post-operative Prostate Cancer." In: *TVCG* (2018). ISSN: 1077-2626.
- [3] L. Franklin et al. "TreatmentExplorer: an Interactive Decision Aid for Medical Risk Communication and Treatment Exploration." In: *Interacting with Computers* 28.3 (2016).
- [4] A. Hakone et al. "PROACT: Iterative Design of a Patient-Centered Visualization for Effective Prostate Cancer Health Risk Communication." In: *TVCG* 23.1 (2017).
- [5] R. P. Myers, J. C. Cheville, and W. Pawlina. "Making anatomic terminology of the prostate and contiguous structures clinically useful: historical review and suggestions for revision in the 21st century." In: *Clin Anat* 23.1 (2010).
- [6] A. S. Purysko et al. "PI-RADS Version 2: A Pictorial Update." In: *Radiographics* 36.5 (2016).
- [7] G. Sauter et al. "Integrating Tertiary Gleason 5 Patterns into Quantitative Gleason Grading in Prostate Biopsies and Prostatectomy Specimens." In: *Eur Urol* 73.5 (2018).
- [8] World Health Organization, GLOBOCAN Project. *Cancer Fact Sheet*. 2012.