Artificial Intelligence in pathology

current applications, limitations,and future directions

Diana Taheri, M.D.

Professor of Renal and Urologic Pathology

Urology Research Center, Tehran University of Medical Sciences

Isfahan Kidney Diseases Research Center, Isfahan University of Medical Sciences

AI in Medicine" Webinar, Iran University of Medical Sciences, 11- May- 2024

INTRODUCTION

Automation in Pathology:

- Automated tissue processing, Staining and Generation of synoptic reports
- It progressed to introduction of Digital Pathology (DP)

(which are now under process of approval for primary diagnosis)

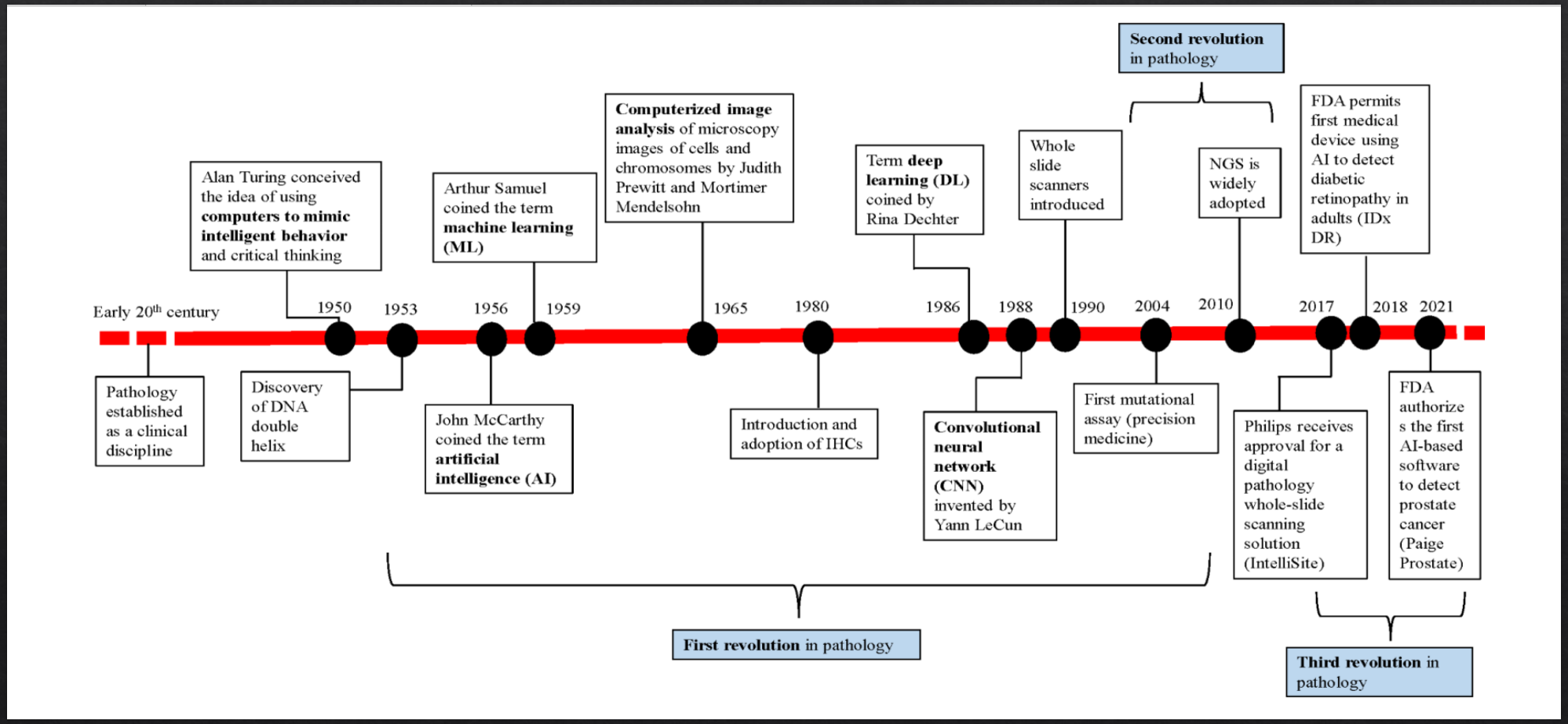
- DP allows remote diagnostic reporting with flexible hours and facilitates second and expert opinion reporting
- DP enables implementation of Artificial Intelligence (AI) based algorithms in routine practice
- The integration of AI will be the milestone for healthcare in the next decade

Uses of Digital Images

- Telepathology for consultation
- Multidisciplinary meeting (Tumor Board), Conferences, Presentation
- Documentation, Pathology reports
- Archiving
- Quality Assurance
- Primary pathology diagnosis
- Remote intra- operative consultation
- Nonclinical- Research, Education, Legal situations

Open doors for application of Artificial Intelligence in Pathology

Schematic Representation of the How Artificial Inteligence(AI) can be Applied in the Practice of Pathology



Shafi and Parwani *Diagnostic Pathology* (2023) 18:109

Why AI In Pathology

- Precision medicine demands precision diagnostics
- The pathologist's diagnosis based on histological slides is at the center of clinical management especially decisions on cancer care
- This emphasizes the need of accuracy in histopathological diagnosis for personalized therapy
- Discordance among pathologist is common as seen in assessing certain subjective features like cytonuclear pleomorphism/degree of atypia cellularity, counting mitotic figures, scoring of tumor infiltrating lymphocytes and assessment of proliferation (Ki67) index
- The end point of traditional microscope slide evaluation is Quantitative assessment of changes in cell number, morphology and distribution
- AI is being anticipated to help pathologists in transition from providing just traditional qualitative (discriptive0 reports to more Quantitative results

Application of AI in Pathology

- Finding tumor deposits within lymph nodes- as a screening method to reduce the work- load of pathologists
- Detection and grading of cancer- whether the tissue studied harbor tumor or not, if present to do tumor typing, grading
    - Gleason grading have been achieved in prostate cancer
    - Method to automatically detect mitotic figures in brest cancer tissue sections
- Support and improve the quantification, especially in immunohistochemistry (stain intensity), resulting in accurate measurement, therby reproducibility

Application of AI in Pathology- Cont

- Measurement of tumor sizes or distances to resection margins will be more objective compared to classical microscopy
- Enables to create smooth workflow

enables the experts doing expert work and generalists doing general Pathology

- Text feature Extraction

connected to pathology reports, structure or extract specific text parts from routine pathology reports for further scientific purposes

- Text interpretation and codeing error prevention

preventive error correction

- One of the major milestones is the:

Food and Drug Administration approval of Paige prostate AI for a second review of prostate cancer diagnosed using core needle biopsies.

- However, implementation of these AI tools for routine prostate cancer diagnostics is still lacking.

Paige prostate AI

REVIEW ARTICLE

Artificial Intelligence-Enabled Prostate Cancer Diagnosis and Prognosis: Current State and Future Implications

Swati Satturwar, MD and Anil V. Parwani, MD, PhD, MBA

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Abstract: In this modern era of digital pathology, artificial intelligence (AI)-based diagnostics for prostate cancer has become a hot topic. Multiple retrospective studies have demonstrated the benefits of AI-based diagnostic solutions for prostate cancer that includes improved prostate cancer detection, quantification, grading, interobserver concordance, cost and time savings, and a potential to reduce pathologists' workload and enhance pathology laboratory workflow. One of the major milestones is the Food and Drug Administration approval of Paige prostate AI for a second review of prostate cancer diagnosed using core needle biopsies. However,

architectural patterns and other features required for the pathologic diagnosis of prostate cancer (PC).[4–6]

PC diagnosis and Gleason grading in core needle biopsies (CNBs) of the prostate are critical for deciding further management of the patients.[7,8] Gleason grading on biopsies is a time-consuming task and suffers from poor interobserver reproducibility even among the subspecialized pathologists and results in either under-grading or over-grading of PC,[9–15] leading to under-treatment or over-treatment of PC patients. AI-based diagnostics for PC has the potential to outperform

Adv Anat Pathol , Volume 31, Number 2, March 2024

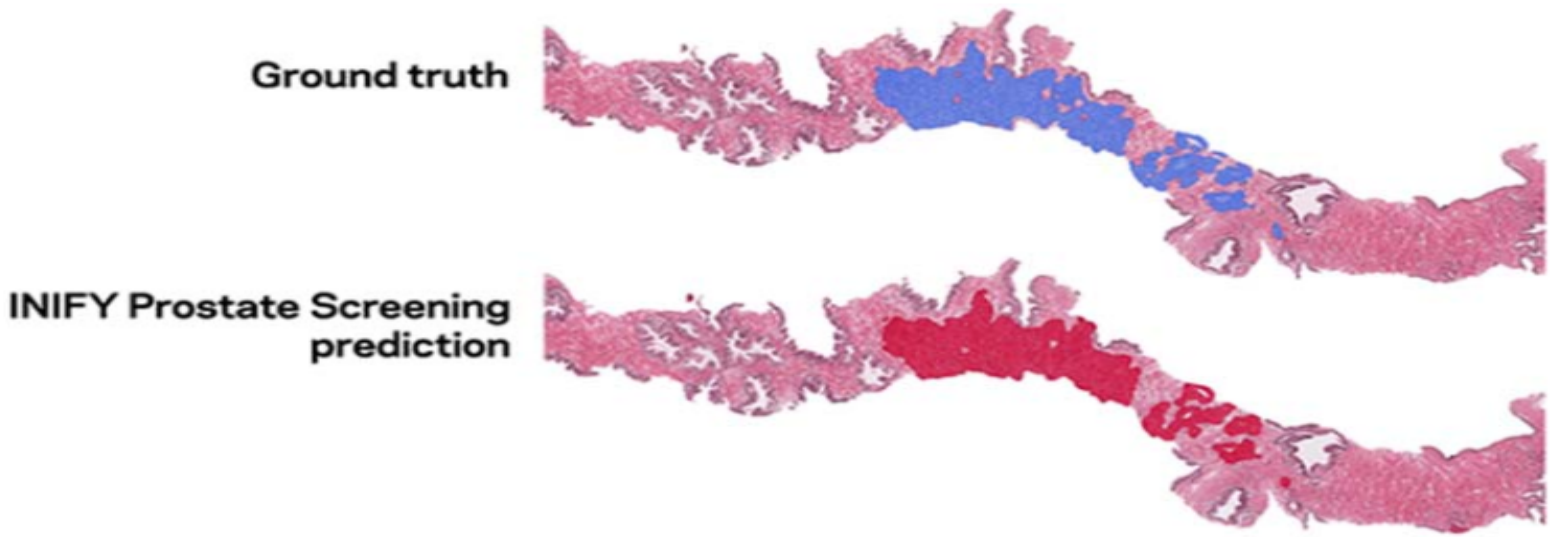
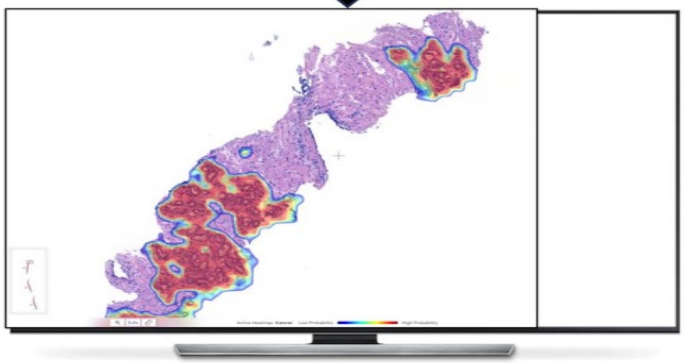


FIGURE 1. AI algorithm by INIFY prostate for detection of prostate cancer on core needle biopsy. Top panel shows a blue heatmap (ground truth) of the prostate cancer area identified and annotated by a pathologist and the bottom panel shows an identical red heatmap of prostate cancer. AI indicates artificial intelligence. INIFY indicate Inify laboratories in Sweden.

- Worklist with pre-classified cases
- Red color indicates cancer

Artificial intelligence algorithm



Output by AI algorithm:
- Red heatmap highlighting cancer
- Gleason score
- Tumor length
- Tumor proportion
- Grade Group
- Perineural invasion

Artificial intelligence algorithm

- Prognosis score to predict risk of biochemical relapse and metastasis

FIGURE 2. AI algorithm flowchart for prostate cancer diagnosis and prognosis. AI indicates artificial intelligence. Please see this image in color online.

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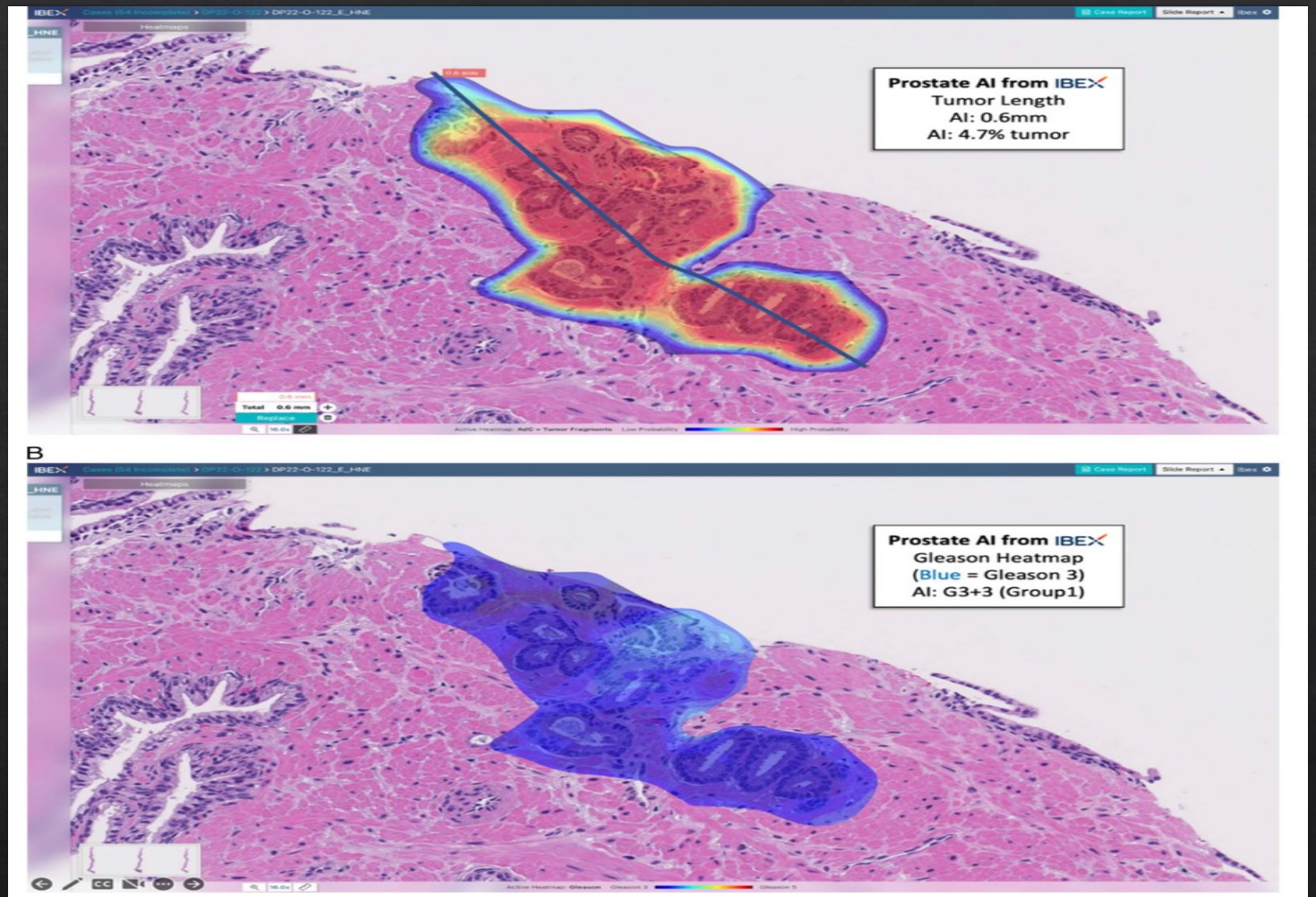


IGURE 3. A-B, AI algorithm by IBEX showing tumor length, percent involvement of the core by prostate cancer on a core needle biopsy A, Top core red heatmap) and showing Gleason score and grade group of prostate cancer in the bottom core (B, blue heatmap). AI ndicates artificial intelligence. Please see this image in color online.

CURRENT CHALLENGES FOR DEPLOYMENT OF AI TOOLS FOR PC DIAGNOSIS

TABLE 3. Limitations of Currently Available AI Algorithms for Histopathologic Diagnosis of Prostate Cancer

1. Need costly digital pathology workflow for integration of AI-based diagnostics
2. None of the currently available AI algorithm is 100% perfect and needs human supervision
3. Lack of accountability for missed diagnoses
4. Susceptibility to changes in input data leading to variable performance in different settings
5. Lack of large-scale studies with external validation
6. Lack of prospective large-scale studies
7. Lack of clinical trials assessing the impact of AI-based diagnostics
8. Non-superior to specialist GU pathologist
9. Potential to cause de-skilling of pathologists
10. Lack of regulatory guidelines for deployment of AI tools

Potential Advantages and Future Prospect of AI-based Diagnostics for PC

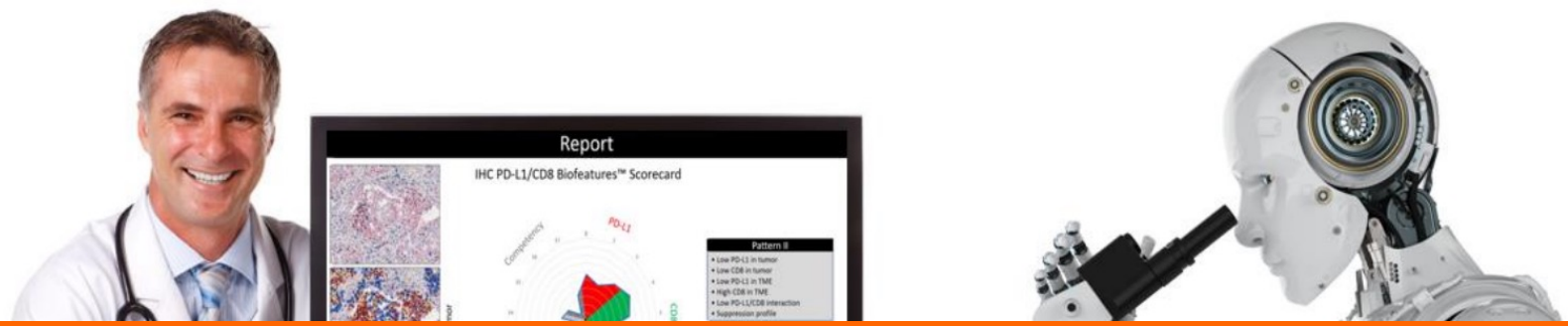
Potential advantages
1. Reduced workload
2. Improved prostate cancer detection
3. Improved/better quantification of prostate cancer on CNBs
4. Improved grading of PC
5. Decreased turnaround time
6. Enhance pathology workflow
7. Improved overall performance of reporting of prostate CNBs by nonspecialists and specialist pathologists
8. Cost savings due to decreased use of IHC for diagnosing prostate cancer on CNBs
9. Enhanced learning experience of pathology trainees
10. Chance to reduce health care inequalities in different parts of the world by unanimous use of these standardized AI tools for PC diagnosis

Potential Advantages and Future Prospect of AI-based Diagnostics for PC

Future prospect of AI-based diagnostics for prostate cancer

1. As pre–sign-out screening tool
2. As a quality control tool for post–sign-out cases
3. Real-time pathologist digital diagnostic assist tool
4. For the second review of challenging cases
5. Routine primary diagnosis with pathologist supervision
6. Routine primary diagnosis of negative prostate biopsy cases without pathologist supervision
7. Deploying automated templates for reporting prostate cancer CNBs
8. Research aspect of AI as a tool to improve the understanding of the biology of prostate cancers and beyond
9. Combining pathology with radiomics and genomics to provide the highest level of integrated diagnosis for urologic cancers

Pathologist vs Artificial Intelligence: Competition or collaboration?



multimodal approach using proteomics, genomics,and AI-based multiplexed biomarker quantifications,
might be necessary for comprehensive patient-specific tumor precision therapy

Thank you for your attention

These are exciting times, as pathology finally seems poised to take advantage
Of notable advances in microscopy and computation