



## EDITORIAL

# AtlasGPT: dawn of a new era in neurosurgery for intelligent care augmentation, operative planning, and performance

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**T**HE primary objective of this editorial is to introduce what we believe to be the next wave of technology poised to revolutionize neurosurgical care and knowledge (all subspecialties of neurosurgery) as we currently understand it—the development of extended specialty-focused large language models (LLMs) in medicine. We describe AtlasGPT, an LLM based on reliable peer-reviewed neurosurgery-specific data sources.

Over the past 5 years, artificial intelligence (AI), accelerated dramatically by the advent of ChatGPT and GPT-4, has emerged as a mainstream force at the forefront of innovation, with applications relevant across industries.<sup>1–12</sup> Although the prowess of LLMs such as ChatGPT and GPT-4 is undeniably impressive, these algorithms are optimized to plausibly complete language patterns, not serve as databases of trustworthy information.

Scientists and specialists alike are actively pushing the boundaries of these technologies to solve complex problems that challenge the world's most foremost experts in their respective fields,<sup>1,9,10</sup> and the field of neurosurgery stands as no exception to this transformative trend. Whether it is striving to successfully pass neurosurgical boards or streamlining modern workflows, AI has already begun to revolutionize modern-day medicine.<sup>1,9,10</sup>

As evident from the numerous recent publications focused on LLMs within the realms of medicine and neurosurgery, generative pretraining transformer (GPT) models have showcased remarkable capabilities.<sup>1,5,6,9–12</sup> Nevertheless, considering the intricacy and technical nature of neurosurgical knowledge and decision-making, the credibility of sources used by GPT models and the imperative for

them to return precise answers devoid of any error take on paramount significance.<sup>1,5,6,9–12</sup>

In light of this need, we have extended the application of ChatGPT and other GPT models by introducing an innovative modification specifically tailored to cater to the needs of neurosurgeons—AtlasGPT. This newly proposed cutting-edge adaptation, created with a specialized training regimen, provides neurosurgeons with incredibly accurate answers to their prompts and questions.

AtlasGPT uses cutting-edge retrieval-augmented generation (RAG) techniques to mitigate risks and ensure the highest standards of output.<sup>13,14</sup> These models, notable for their dual-process architecture, combine the generative strength of LLMs with an external data retrieval mechanism. This approach is rapidly gaining popularity as a result of its ability to integrate up-to-date and relevant information from external sources into its responses. By doing so, RAG models enhance the accuracy and relevance of generated content, which addresses a key limitation of traditional LLMs. RAG architecture introduces a pivotal filtering and ranking step in the initial query—the retrieval step (Fig. 1).<sup>13,14</sup>

Upon receiving any prompt, the model initiates a process to source and retrieve pertinent data and sources, predetermined during the training phase of model development. After retrieving relevant articles, passages, or partitions from a large, predefined language corpus, the model integrates the information with the user's initial prompt.<sup>13,14</sup> This collaborative approach provides the GPT model with sufficient context to deliver a truthful and accurate answer. In addition, the complexity and tone of the

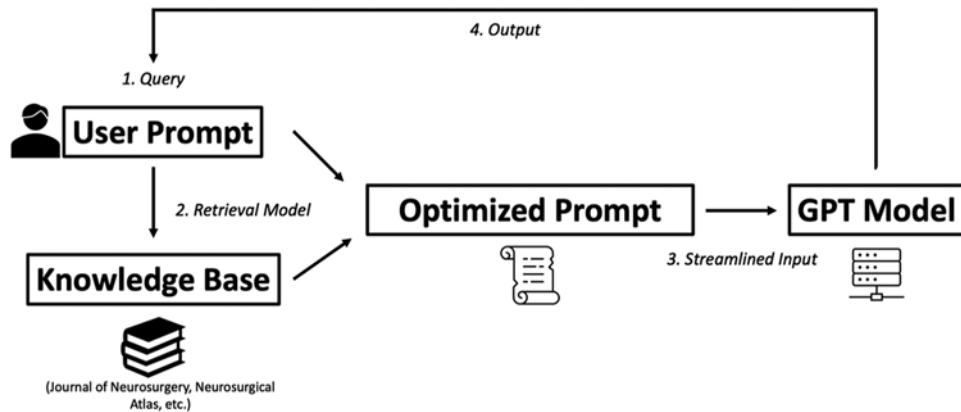


FIG. 1. Schematic of selective RAG of AtlasGPT for improving the accuracy and validity of LLM responses.

response can be adjusted according to the level of medical knowledge of the user or target audience; options include patient, medical student, resident, and practicing neurosurgeon styles.

The implementation architecture can be scaled and integrated easily. Two bespoke integrations have already been completed using the representational state transfer architectural style application programming interface (REST API) of the platform. Automated ingestion pipelines are also in place to ensure that AtlasGPT remains up to date and relevant over time.

AtlasGPT places significant emphasis on the retrieval step and extensively leverages pretrained neurosurgical literature, encompassing sources such as the *Journal of Neurosurgery*, *The Neurosurgical Atlas*, and various peer-reviewed neurosurgical publications. As of December 2023, AtlasGPT had undergone training using 250,000 pages of meticulously selected peer-reviewed neurosurgical articles. This careful curation is aimed at streamlining and facilitating the production of reliable outputs that align with the exacting standards set by the world’s leading neurosurgical journals. The potential uses for such a highly specialized and expansive language model are virtually limitless; select applications of AtlasGPT are listed in Table 1, and we present an example query and response from AtlasGPT in Fig. 2 to show its potential applications. AtlasGPT will continue to evolve with time to include image recognition and other applications of computer vision. In addition, its knowledge base will continue to increase, further expanding its capabilities for transforming neurosurgery.

As Sir Francis Bacon noted, “ipsa scientia potestas est” (“knowledge itself is power”). However, with the advent of AtlasGPT we could rephrase this quote as “scientia accessibilis est potentia accessibilis” (“accessible knowledge is accessible power”). AI LLMs such as AtlasGPT are opening up a future in which vast amounts of knowledge can be shared by creative minds for better neurosurgical care.

We hope that you share our enthusiasm for AtlasGPT and its potential to facilitate the acquisition of new knowledge to enable you to provide the best possible care for your patients.

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TABLE 1. Select applications for AtlasGPT

Creation of management strategies for complex patient cases using evidence-based management algorithms with peer-reviewed references
Procedural guidance for highly technical operations, with procedure steps, key considerations, and decision-making insights with relevant literature references for procedural preparation
Intraoperative queries to surgical questions related to patient positioning, anatomical considerations, or specific steps of a procedure
Decision-making for surgery, including decision-making processes and recommendations for evidence-based approaches to determine surgical candidacy
Literature sourcing for complex cases to inform management decisions, especially for rare or challenging patient cases not commonly encountered
Generation of customized patient-specific educational materials that explain complex neurosurgical conditions and procedures in layman’s terms
Research acceleration via its ability to sift through vast amounts of literature quickly, identify gaps in the current knowledge base, and suggest potential areas for new research
Data synthesis and meta-analysis assistance by synthesizing data from various studies, facilitating meta-analyses, and summarizing findings in neurosurgery
Grant writing assistance by providing relevant background information and data analysis and aligning with funding agency priorities
Collaborative research assistance using the creation of platforms for collaboration in which neurosurgeons worldwide could discuss specific cases and share knowledge
Predictive analysis with given patient data to predict outcomes of surgical procedures and help in preoperative planning to improve the probability of better outcomes
Interdisciplinary integration by serving as a bridge to integrate neurosurgery with other fields such as bioengineering, pharmacology, and cognitive science
Publication drafting assistance with writing and formatting research papers, abstracts, and presentations, saving valuable time for researchers

How do I reduce a fracture dislocation during surgery for a T12 Chance fracture ?

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Reduction of a T12 Chance fracture–dislocation involves realigning the vertebral column to restore anatomical integrity and relieve pressure on the neural elements. Here are the steps for intraoperative reduction:

1. **Exposure:** After the patient is positioned and prepped, perform a midline incision and subperiosteal dissection to expose the posterior elements of the spine at and around the level of the fracture.
  2. **Instrumentation Placement:** Insert pedicle screws above and below the level of the fracture using fluoroscopic guidance or neuronavigation to ensure accurate placement.
  3. **Temporary Rod Placement:** Attach a temporary contoured rod to the screws on one side to provide initial stabilization.
  4. **Fracture Reduction:** Utilize the pedicle screws as reduction tools. This can be achieved by manipulating the screws with reduction instruments, such as rod reducers or screw extenders, to realign the vertebral bodies. Apply longitudinal traction and corrective forces as needed to reduce any kyphotic deformity and translation.
  5. **Confirmation of Reduction:** Use intraoperative fluoroscopy to confirm that the vertebral bodies are properly aligned and that the spinal canal is decompressed.
  6. **Definitive Rod Placement:** Once the fracture is reduced, place the definitive contoured rods bilaterally and secure them to the pedicle screws. Apply compression across the fracture site to maintain the reduction and facilitate healing.
  7. **Crosslink Placement:** If necessary, add crosslinks between the rods to increase the construct's rigidity.
  8. **Bone Grafting:** Perform decortication of the laminae and facet joints, and place bone graft material to promote fusion across the fracture site.
  9. **Closure:** After ensuring hemostasis, close the surgical site in layers, possibly placing a drain if significant dead space or bleeding is present.
  10. **Postoperative Imaging:** Obtain postoperative spinal imaging to verify the final position of the hardware and the adequacy of the reduction.
- Throughout the procedure, maintain continuous neuromonitoring to detect any changes in SSEPs and MEPs, indicating potential neural compromise. Adjust the reduction maneuvers accordingly to prevent iatrogenic injury.

**FIG. 2.** Response from AtlasGPT to a question regarding the management of a Chance fracture. This response is in “surgeon style,” but it could easily be adjusted to the knowledge level of a resident, medical student, or patient. MEP = motor evoked potential; SSEP = somatosensory evoked potential.

## References

1. Hopkins BS, Nguyen VN, Dallas J, et al. ChatGPT versus the neurosurgical written boards: a comparative analysis of artificial intelligence/machine learning performance on neurosurgical board–style questions. *J Neurosurg.* 2023;139(3):904-911.
2. Hopkins BS, Murthy NK, Texakalidis P, et al. Mass deployment of deep neural network: real-time proof of concept with screening of intracranial hemorrhage using an open data set. *Neurosurgery.* 2022;90(4):383-389.
3. Hopkins BS, Yamaguchi JT, Garcia R, et al. Using machine learning to predict 30-day readmissions after posterior lumbar fusion: an NSQIP study involving 23,264 patients. *J Neurosurg Spine.* 2019;32(3):399-406.
4. Hopkins BS, Weber KA II, Kesavabhotla K, Paliwal M, Cantrell DR, Smith ZA. Machine learning for the prediction of cervical spondylotic myelopathy: a post hoc pilot study of 28 participants. *World Neurosurg.* 2019;127:e436-e442.
5. Ali R, Tang OY, Connolly ID, et al. Performance of ChatGPT, GPT-4, and Google Bard on a neurosurgery oral boards preparation question bank. *Neurosurgery.* Published online June 12, 2023. doi:10.1227/neu.0000000000002551
6. Ali R, Tang OY, Connolly ID, et al. Performance of ChatGPT and GPT-4 on neurosurgery written board examinations. *Neurosurgery.* 2023;93(6):1353-1365.
7. Danilov G, Kotik K, Shevchenko E, et al. Predicting the length of stay in neurosurgery with RuGPT-3 language model. *Stud Health Technol Inform.* 2022;295:555-558.
8. Danilov G, Kotik K, Shevchenko E, et al. Length of stay prediction in neurosurgery with Russian GPT-3 language model compared to human expectations. *Stud Health Technol Inform.* 2022;289:156-159.
9. Guerra GA, Hofmann H, Sobhani S, et al. GPT-4 artificial

- intelligence model outperforms ChatGPT, medical students, and neurosurgery residents on neurosurgery written board-like questions. *World Neurosurg.* 2023;179:e160-e165.
10. Kuang YR, Zou MX, Niu HQ, Zheng BY, Zhang TL, Zheng BW. ChatGPT encounters multiple opportunities and challenges in neurosurgery. *Int J Surg.* 2023;109(10):2886-2891.
  11. Li W, Fu M, Liu S, Yu H. Revolutionizing neurosurgery with GPT-4: a leap forward or ethical conundrum? *Ann Biomed Eng.* 2023;51(10):2105-2112.
  12. Resnick DK. Commentary: Performance of ChatGPT, GPT-4, and Google Bard on a neurosurgery oral boards preparation question bank. *Neurosurgery.* Published online July 19, 2023. doi:10.1227/neu.0000000000002618
  13. Wang C, Ong J, Wang C, Ong H, Cheng R, Ong D. Potential for GPT technology to optimize future clinical decision-making using retrieval-augmented generation. *Ann Biomed Eng.* Published online August 2, 2023. doi:10.1007/s10439-023-03327-6
  14. Lewis P, Perez E, Piktus A, et al. Retrieval-augmented generation for knowledge-intensive NLP tasks. *arXiv.* Preprint posted online May 22, 2020. doi:10.48550/arXiv.2005.11401

## Disclosures

Dr. Carter reported serving as a Board Member for *The Neurosurgical Atlas* during the conduct of the study. Mr. Lord reported a patent for Self Accelerating System and Method for Data Retrieval with a Proximity-Based Tiered Ranking Algorithm pending to Jesse Lord and Ole Anders Andersen. Dr. Cohen-Gadol reported being a shareholder in Atlas Meditech during the conduct of the study.

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