Stanford

Carla Pugh, MD, PhD

Thomas Krummel Professor

Surgery - General Surgery

Curriculum Vitae available Online

CLINICAL OFFICE (PRIMARY)

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ACADEMIC CONTACT INFORMATION

- **Administrative Contact**

  Audrey Bowler - Executive Administrator

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Bio

BIO

Carla Pugh is Professor of Surgery at Stanford University School of Medicine. She is also the Director of the Technology Enabled Clinical Improvement (T.E.C.I.) Center. Her clinical area of expertise is Acute Care Surgery. Dr. Pugh obtained her undergraduate degree at U.C. Berkeley in Neurobiology and her medical degree at Howard University School of Medicine. Upon completion of her surgical training at Howard University Hospital, she went to Stanford University and obtained a PhD in Education. She is the first surgeon in the United States to obtain a PhD in Education. Her goal is to use technology to change the face of medical and surgical education.

Her research involves the use of simulation and advanced engineering technologies to develop new approaches for assessing and defining competency in clinical procedural skills. Dr. Pugh holds three patents on the use of sensor and data acquisition technology to measure and characterize hands-on clinical skills. Currently, over two hundred medical and nursing schools are using one of her sensor enabled training tools for their students and trainees. Her work has received numerous awards from medical and engineering organizations. In 2011 Dr. Pugh received the Presidential Early Career Award for Scientists and Engineers from President Barak Obama at the White House. She is considered to be a lead, international expert on the use of sensors and motion tracking technology for performance measurement. In 2014 she was invited to give a TEDMED talk on the potential uses of technology to transform how we measure clinical skills in medicine. In April 2018, Dr. Pugh was inducted into the American Institute for Medical and Biological Engineering.

CLINICAL FOCUS

- General Surgery

ACADEMIC APPOINTMENTS

- Professor, Surgery - General Surgery
- Member, Wu Tsai Human Performance Alliance
- Member, Stanford Cancer Institute

PROFESSIONAL EDUCATION

- Fellowship: University of Michigan Medical School (2009) MI
- PhD, Stanford University Graduate School of Education , Education & Technology (2001)
- Board Certification: General Surgery, American Board of Surgery (1999)
- Residency: Howard University Hospital General Surgery Residency (1997) DC
- Medical Education: Howard University College of Medicine (1992) DC

LINKS

- Getting a Sense for the Surgical Touch: https://www.youtube.com/watch?v=k9D-vxGkHTc
- LinkedIn: https://www.linkedin.com/in/carla-pugh-2ab0b511b/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The Technology Enabled Clinical Improvement (T.E.C.I.) Center is a multidisciplinary team of researchers dedicated to the design and implementation of advanced engineering technologies that facilitate data acquisition relating to clinical performance.

The T.E.C.I. team has had great success in quantifying physicians' clinical experiences using sensor, video, and motion tracking technologies. This work has resulted in an information rich database that enables empirical evaluation of clinical excellence and medical decision making.

By leveraging highly specific and objective clinical performance metrics, the T.E.C.I. Center is harnessing the unique opportunity to support peer to peer data sharing and clinical collaborations that can transform the clinical workflow and ultimately benefit healthcare providers.

The T.E.C.I. Center aims to transform human health and welfare through advances in data science and personalized, technology-based performance metrics for healthcare providers.

Teaching

STANFORD ADVISEES

Postdoctoral Faculty Sponsor

Calvin Perumalla

Publications

PUBLICATIONS

- **Opportunities and Applications of Educational Technologies in Surgical Education and Assessment.** *Annals of surgery*
  Fried, G. M., Varas, J., Telem, D. A., Greenberg, C. C., Hashimoto, D. A., Paige, J. T., Pugh, C.
  2024
- **Precision Education: The Future of Lifelong Learning in Medicine.** *Academic medicine : journal of the Association of American Medical Colleges*
  Desai, S. V., Burk-Rafel, J., Lomis, K. D., Caverzagie, K., Richardson, J., O'Brien, C. L., Andrews, J., Heckman, K., Henderson, D., Prober, C. G., Pugh, C. M., Stern, S. D., Triola, et al
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- **Sensor-Based Discovery of Search and Palpation Modes in the Clinical Breast Examination.** *Academic medicine : journal of the Association of American Medical Colleges*
  Laufer, S., Klatzky, R. L., Pugh, C. M.

2024

- **Foreword: The Next Era of Assessment and Precision Education.** *Academic medicine : journal of the Association of American Medical Colleges*
  Schumacher, D. J., Santen, S. A., Pugh, C. M., Burk-Rafel, J.
  2023

- **Haptics: The Science of Touch as a Foundational Pathway to Precision Education and Assessment.** *Academic medicine : journal of the Association of American Medical Colleges*
  Perrone, K., Abdelaal, A. E., Pugh, C., Okamura, A.
  2023

- **Surgical Education.** *Annals of surgery*
  Farmer, D. L., O'Connell, P. R., Pugh, C. M., Lang, H., Greenberg, C. C., Borel-Rinkes, I. H., Mellinger, J. D., Pinto-Marques, H.
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- **Surgical Instant Replay-A National Video-Based Performance Assessment Toolbox.** *JAMA surgery*
  Yule, S., Dearani, J. A., Pugh, C.
  2023

- **SAGES consensus recommendations on surgical video data use, structure, and exploration (for research in artificial intelligence, clinical quality improvement, and surgical education).** *Surgical endoscopy*
  Eckhoff, J. A., Rosman, G., Altieri, M. S., Speidel, S., Stoyanov, D., Anvari, M., Meier-Hein, L., Marz, K., Jannin, P., Pugh, C., Wagner, M., Witkowski, E., Shaw, et al
  2023

- **Allyship in action: The critical, missing link to crossing the quality chasm in healthcare.** *American journal of surgery*
  Pugh, C. M.
  2023

- **Laying the Groundwork for Optimized Surgical Feedback.** *JAMA network open*
  Shkolyar, E., Pugh, C., Liao, J. C.
  2023; 6 (6): e2320465

- **Promoting breast health awareness: Can a sensor-enabled training system for patient education help?** *American journal of surgery*
  Kearse, L., Goll, C., Wise, B., Yang, S., Mohamadipanah, H., Witt, A., Ratliff, P., Pugh, C.
  2023

- **The Quantified Surgeon: A Glimpse Into the Future of Surgical Metrics and Outcomes.** *The American surgeon*
  Pugh, C. M.
  2023: 31348231168315

- **Response to: Comment on The AI and I: A Collaboration on Competence.** *Annals of surgery open : perspectives of surgical history, education, and clinical approaches*
  Funk, L. M., Pugh, C. M.
  2023; 4 (1): e272

- **Reclaiming the Calendar: Time Management for the Clinician Educator.** *Journal of graduate medical education*
  Pitre, C. J., Pugh, C. M.
  2023; 15 (1): 117-118

- **An American Board of Surgery Pilot of Video Assessment of Surgeon Technical Performance in Surgery.** *Annals of surgery*
  Pryor, A. D., Lendvay, T., Jones, A., Ibáñez, B., Pugh, C.
  2023

- **Addressing the Surgical Workplace: An Opportunity to Create a Culture of Belonging.** *Annals of surgery*
  Pugh, C. M., Kirton, O. C., Tuttle, J. E., Maier, R. V., Hu, Y., Stewart, J. H., Freischlag, J. A., Sosa, J. A., Vickers, S. M., Hawn, M. T., Eberlein, T. J., Farmer, D. L., Higgins, et al
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- **Generating Rare Surgical Events Using CycleGAN: Addressing Lack of Data for Artificial Intelligence Event Recognition.** *The Journal of surgical research*
  Mohamadipanah, H., Kearse, L., Wise, B., Backhus, L., Pugh, C.

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- **AI-Based Video Segmentation: Procedural Steps or Basic Maneuvers?** *The Journal of surgical research*
  Perumalla, C., Kearse, L., Peven, M., Laufer, S., Goll, C., Wise, B., Yang, S., Pugh, C.
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- **Annals of Surgery Open Access: Where is the Value, and What does the Future Hold?** *Annals of surgery*
  Funk, L. M., Barr, J., Johnston, F. M., Smith, B. K., Cooper, Z., Pugh, C., Dimick, J. B., Clavien, P., Read, T. E., Wong, S. L.
  2022

- **Society of Black Academic Surgeons (SBAS) diversity, equity, and inclusion series: Microaggressions - Lessons Learned from Black Academic Surgeons.** *American journal of surgery*
  Butler, P. D., Wexner, S. D., Alimi, Y. R., Dent, D. L., Fayanju, O. M., Gantt, N. L., Johnston, F. M., Pugh, C. M.
  2022

- **Do Individual Surgeon Preferences Affect Procedural Outcomes?** *Annals of surgery*
  Mohamadipanah, H., Perumalla, C. A., Kearse, L. E., Yang, S., Wise, B. J., Goll, C. K., Witt, A. K., Korndorffer, J. R., Pugh, C. M.
  2022

- **Open surgery tool classification and hand utilization using a multi-camera system.** *International journal of computer assisted radiology and surgery*
  Basiev, K., Goldbraikh, A., Pugh, C. M., Laufer, S.
  2022

- **Artificial intelligence in surgery: A research team perspective.** *Current problems in surgery*
  Mohamadipanah, H., Perumalla, C., Yang, S., Wise, B., Kearse, L., Goll, C., Witt, A., Korndorffer, J. R., Pugh, C.
  2022; 59 (6): 101125

- **Artificial Intelligence Methods and Artificial Intelligence-Enabled Metrics for Surgical Education: A Multidisciplinary Consensus.** *Journal of the American College of Surgeons*
  Vedula, S. S., Ghazi, A., Collins, J. W., Pugh, C., Stefanidis, D., Meireles, O., Hung, A. J., Schwaitzberg, S., Levy, J. S., Sachdeva, A. K., and the Collaborative for Advanced Assessment of Robotic Surgical Skills, Stoyanov, D., Chen, C. C., et al
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- **In Brief.** *Current problems in surgery*
  Mohamadipanah, H., Perumalla, C., Yang, S., Wise, B., Kearse, L., Goll, C., Witt, A., Korndorffer, J. R., Pugh, C.
  2022; 59 (6): 101127

- **Using open surgery simulation kinematic data for tool and gesture recognition.** *International journal of computer assisted radiology and surgery*
  Goldbraikh, A., Volk, T., Pugh, C. M., Laufer, S.
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- **A disturbing trend: An analysis of the decline in surgical critical care (SCC) fellowship training of Black and Hispanic surgeons.** *The journal of trauma and acute care surgery*
  Hambrecht, A., Berry, C., DiMaggio, C., Chiu, W., Inaba, K., Frangos, S., Krowsoski, L., Greene, W. R., Issa, N., Pugh, C., Bukur, M.
  2022

- **Diversity, equity, and inclusion in presidential leadership of academic medical and surgical societies.** *American journal of surgery*
  Kearse, L. E., Goll, C. K., Jensen, R. M., Wise, B. J., Witt, A. K., Huemer, K., Korndorffer, J. R., Pugh, C. M.
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- **Invited Commentary: Dissecting the Mentorship Needs of Women and Ethnic Minorities in Surgery: New Opportunities Revealed.** *Journal of the American College of Surgeons*
  Pugh, C.
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- **Examination of Intersectionality and the Pipeline for Black Academic Surgeons.** *JAMA surgery*
  Keshinro, A., Butler, P., Fayanju, O., Khabele, D., Newman, E., Greene, W., Ude Welcome, A., Joseph, K., Stallion, A., Backhus, L., Frangos, S., DiMaggio, C., Berman, et al
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- **Video-based fully automatic assessment of open surgery suturing skills.** *International journal of computer assisted radiology and surgery*

Goldbraikh, A., D'Angelo, A., Pugh, C. M., Laufer, S.
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- **Developing a longitudinal database of surgical skills performance for practicing surgeons: A formal feasibility and acceptance inquiry.** *American journal of surgery*
  Applewhite, M. K., Kearse, L. E., Mohamadipanah, H., Witt, A., Goll, C., Wise, B., Korndorffer, J. R., Pugh, C. M.
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- **Response to the Comments on "Situating Artificial Intelligence in Surgery, a Focus on Disease Severity'' Reply** *ANNALS OF SURGERY*
  Pugh, C. M., Wolf, T., Korndorffer, J. R.
  2021; 274 (6): E892-E893

- **Response to the Comment on "Situating Artificial Intelligence in Surgery: A Focus on Disease Severity".** *Annals of surgery*
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  Pugh, C. M.
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- **Surgical data science - from concepts toward clinical translation.** *Medical image analysis*
  Maier-Hein, L., Eisenmann, M., Sarikaya, D., Marz, K., Collins, T., Malpani, A., Fallert, J., Feussner, H., Giannarou, S., Mascagni, P., Nakawala, H., Park, A., Pugh, et al
  2021; 76: 102306

- **The Experienced Surgeon and New Tricks-It's Time for Full Adoption and Support of Automated Performance Metrics and Databases.** *JAMA surgery*
  Pugh, C. M.
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- **Performance assessment using sensor technology.** *Journal of surgical oncology*
  Mohamadipanah, H., Wise, B., Witt, A., Goll, C., Yang, S., Perumalla, C., Huemer, K., Kearse, L., Pugh, C.
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- **SAGES consensus recommendations on an annotation framework for surgical video.** *Surgical endoscopy*
  Meireles, O. R., Rosman, G., Altieri, M. S., Carin, L., Hager, G., Madani, A., Padoy, N., Pugh, C. M., Sylla, P., Ward, T. M., Hashimoto, D. A., SAGES Video Annotation for AI Working Groups
  2021

- **From Listening to Action: Academic Surgcial Departmental Response to Social Injustice Through Curricular Development.** *Annals of surgery*
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- **Response to: Comments on "Situating Artificial Intelligence in Surgery, a Focus on Disease Severity".** *Annals of surgery*
  Pugh, C. M., Wolf, T., Korndorffer, J. R.
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- **Reassessing career pathways of surgical leaders: An examination of surgical leaders' early accomplishments.** *American journal of surgery*
  Meer, E. n., Hughes, B. D., Martin, C. A., Rios-Diaz, A. J., Patel, V. n., Pugh, C. M., Berry, C. n., Stain, S. C., Britt, L. D., Stein, S. L., Butler, P. D.
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- **Can Deep Learning Algorithms Help Identify Surgical Workflow and Techniques?** *The Journal of surgical research*
  Mohamadipanah, H., Kearse, L., Witt, A., Wise, B., Yang, S., Goll, C., Pugh, C.
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- **How Wearable Technology Can Facilitate AI Analysis of Surgical Videos.** *Annals of surgery open : perspectives of surgical history, education, and clinical approaches*
  Pugh, C. M., Ghazi, A., Stefanidis, D., Schwaitzberg, S. D., Martino, M. A., Levy, J. S.
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  Korndorffer, J. R., Hawn, M. T., Spain, D. A., Knowlton, L. M., Azagury, D. E., Nassar, A. K., Lau, J. N., Arnow, K. D., Trickey, A. W., Pugh, C. M.

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  Korndorffer, J. R., Hawn, M. T., Spain, D. A., Knowlton, L. M., Azagury, D. E., Nassar, A. K., Lau, J. N., Arnow, K. D., Trickey, A. W., Pugh, C. M.
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- **Quantifying Performance Decline in the Operating Room Using fNIRS.** *Annals of surgery*
  Pugh, C. M.
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- **Evaluating how residents talk and what it means for surgical performance in the simulation lab** *AMERICAN JOURNAL OF SURGERY*
  D'angelo, A. D., Ruis, A. R., Collier, W., Shaffer, D., Pugh, C. M.
  2020; 220 (1): 37–43

- **The what? How? And who? Of video based assessment.** *American journal of surgery*
  Pugh, C. M., Hashimoto, D. A., Korndorffer, J. R.
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- **Does the location of short-arm cast univalve effect pressure of the three-point mould?** *Journal of children's orthopaedics*
  Montgomery, B. K., Perrone, K. H., Yang, S., Segovia, N. A., Rinsky, L., Pugh, C. M., Frick, S. L.
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- **Sensors and Psychomotor Metrics: A Unique Opportunity to Close the Gap on Surgical Processes and Outcomes.** *ACS biomaterials science & engineering*
  Mohamadipanah, H., Perrone, K. H., Peterson, K., Nathwani, J., Huang, F., Garren, A., Garren, M., Witt, A., Pugh, C.
  2020; 6 (5): 2630-2640

- **Sensors and Psychomotor Metrics: A Unique Opportunity to Close the Gap on Surgical Processes and Outcomes** *ACS BIOMATERIALS SCIENCE & ENGINEERING*
  Mohamadipanah, H., Perrone, K. H., Peterson, K., Nathwani, J., Huang, F., Garren, A., Garren, M., Witt, A., Pugh, C.
  2020; 6 (5): 2630–40

- **Translating motion tracking data into resident feedback: An opportunity for streamlined video coaching**
  Perrone, K. H., Yang, S., Mohamadipanah, H., Wise, B., Witt, A., Goll, C., Pugh, C.
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- **A Call to Action: Black/African American Women Surgeon Scientists, Where are They?** *Annals of surgery*
  Berry, C., Khabele, D., Johnson-Mann, C., Henry-Tillman, R., Joseph, K., Turner, P., Pugh, C., Fayanju, O. M., Backhus, L., Sweeting, R., Newman, E. A., Oseni, T., Hasson, et al
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- **The Society of Black Academic Surgeons CV benchmarking initiative: Early career trends of academic surgical leaders.** *American journal of surgery*
  Hughes, B. D., Butler, P. D., Edwards, M. A., Pugh, C. M., Martin, C. A.
  2020

- **Benchmarking Accomplishments of Leaders in American Surgery and Justification for Enhancing Diversity and Inclusion.** *Annals of surgery*
  Butler, P. D., Pugh, C. M., Meer, E. n., Lett, L. A., Tilahun, E. D., Sanfey, H. A., Berry, C. n., Stain, S. C., DeMatteo, R. P., Vickers, S. M., Britt, L. D., Martin, C. A.
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- **The Role of Race and Gender in the Career Experiences of Black/African-American Academic Surgeons: A Survey of the Society of Black Academic Surgeons and a Call to Action.** *Annals of surgery*
  Crown, A. n., Berry, C. n., Khabele, D. n., Fayanju, O. M., Cobb, A. n., Backhus, L. n., Smith, R. n., Sweeting, R. n., Hasson, R. n., Johnson-Mann, C. n., Oseni, T. n., Newman, E. A., Turner, et al
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- **Multi-Modal Cardiopulmonary Bypass Skills Assessment within a High-Fidelity Simulation Environment.** *The Annals of thoracic surgery*
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- **Use of sensors to quantify procedural idle time: Validity evidence for a new mastery metric.** *Surgery*
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- **In Search of Characterizing Surgical Skill** *JOURNAL OF SURGICAL EDUCATION*
  Azari, D., Greenberg, C., Pugh, C., Wiegmann, D., Radwin, R.
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- **Screening surgical residents' laparoscopic skills using virtual realitytasks: Who needs more time in the sim lab?** *Surgery*
  Mohamadipanah, H., Perrone, K. H., Nathwani, J., Parthiban, C., Peterson, K., Wise, B., Garren, A., Pugh, C.
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- **Teaching practicing surgeons what not to do: An analysis of instruction fluidity during a simulation-based continuing medical education course**
  Godfrey, M., Rosser, A. A., Pugh, C. M., Shaffer, D., Sachdeva, A. K., Jung, S. A.
  MOSBY-ELSEVIER.2019: 1082–87

- **Advanced Volumetric 3-Dimensional Visualization of Surgical Anatomy-Are We There Yet?** *JAMA surgery*
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  Azari, D., Greenberg, C., Pugh, C., Wiegmann, D., Radwin, R.
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  Pugh, C. M.
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- **Surgical procedural map scoring for decision-making in laparoscopic cholecystectomy** *AMERICAN JOURNAL OF SURGERY*
  Hashimoto, D. A., Axelsson, C., Jones, C. B., Phitayakorn, R., Petrusa, E., McKinley, S. K., Gee, D., Pugh, C.
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- **Can VR Be Used to Track Skills Decay During the Research Years?** *The Journal of surgical research*
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- **Dynamic Visual Feedback During Junctional Tourniquet Training** *JOURNAL OF SURGICAL RESEARCH*
  Xu, J., Kwan, C., Sunkara, A., Mohamadipanah, H., Bell, K., Tizale, M., Pugh, C. M.
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- **Simulation and High-Stakes Assessment** *CLINICAL SIMULATION: EDUCATION, OPERATIONS AND ENGINEERING, 2ND EDITION*
  Lau, J. N., Korndorffer, J. R., Pugh, C. M., Chiniara, G.
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- **Use of error management theory to quantify and characterize residents' error recovery strategies.** *American journal of surgery*
  Pugh, C. M., Law, K. E., Cohen, E. R., D'Angelo, A. D., Greenberg, J. A., Greenberg, C. C., Wiegmann, D. A.
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- **Combining metrics from clinical simulators and sensorimotor tasks can reveal the training background of surgeons.** *IEEE transactions on bio-medical engineering*

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- **What do you want to know? Operative experience predicts the type of questions practicing surgeons ask during a CME laparoscopic hernia repair course.** *American journal of surgery*
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- **A Holistic Model of Surgical Expertise and Competency** *ANNALS OF SURGERY*
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- **Development and validation of assessment measures for a newly developed physical examination simulator** *JOURNAL OF THE AMERICAN MEDICAL INFORMATICS ASSOCIATION*
  Pugh, C. M., Youngblood, P.
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