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Review Article

Galen Wagner, M.D., Ph.D. (1939–2016) as international mentor of young investigators in electrocardiology

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Abstract This paper describes a substantial part of the international mentoring network of students and young investigators in electrocardiology that developed around Dr. Galen Wagner (1939–2016), including many experiences of his mentees and co-mentors.
The paper is meant to stimulate thinking about international mentoring as a means to achieve important learning experiences and personal development of young investigators, to intensify international scientific cooperation, and to stimulate scientific production.

Keywords: International mentoring; Young investigators; Scientific cooperation and production

Introduction

On July 13, 2016, Galen Wagner, M.D., Ph.D., born on December 25, 1939, passed away [1]. He was the Editor-in-Chief of the Journal of Electrocardiology from January 1, 2005 till his death. Several contributions to this commemorative issue of the Journal of Electrocardiology witness of various aspects of his life and work. Being a very productive cardiologist, scientist, teacher and writer, Dr. Wagner has had a remarkable impact in many respects. Without exception, obituaries make mention of one of Dr. Wagner's largest passions, i.e., the mentoring of young persons in the course of their education and initial phase of their professional careers. Dr. Wagner studied at Duke University and remained professionally affiliated with Duke for the rest of his life. In the message sent on July 13 to the Duke University School of Medicine faculty and staff, School Dean Dr. Nancy Andrews writes: *Dr. Wagner may be remembered most for his love of mentoring young people. He was well known for bringing out the best in others, serving as a guide for high school students, undergraduate students, medical students, residents, fellows, and junior and senior faculty.*

In the following, we have addressed one specific form of mentoring that Dr. Wagner was internationally known and respected for, i.e., the mentoring of young investigators during their research projects. Actually, this activity grew naturally on Dr. Wagner's international network of colleagues, as commonly found in the academia. Dr. Wagner initiated and/or participated in numerous cooperative scientific projects. Usually, academic research projects involve young investigators, ranging from undergraduate to doctoral students. In case of cooperation with Dr. Wagner, these young investigators often became mentored by Dr. Wagner, in addition to being mentored by their local mentor (hence, a situation that can be characterized by the word "co-mentorship"). Many times this included a stay of the young investigator at Duke. This University without Walls concept, strongly adhered to by Dr. Wagner, became a source of abundant production of science, as evidenced by the many papers in Dr. Wagner's bibliography [2] that are authored and co-authored by the involved young investigators. Young investigators mentored by Dr. Wagner could benefit from his thorough scientific knowledge, sharp intellect and critical questions, teaching skills in outcomes research [3], which was also part of the mission of the International Research Interdisciplinary Schools [4], but also, and not in the last place, from his authentic involvement and genuine personal interest for the mentee.

The scientific subjects of study were almost invariably connected with electrocardiology. Because of that we

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believe that addressing Dr. Wagner's international mentoring activity in this Journal would be of interest for its readership. Because of the many professional and personal benefits that this mentoring network has offered to many individuals, it is worthwhile to study and follow this concept, in order to create similar benefits for others. We hope that this reading will be appreciated by those who happen to be familiar with (part of) the international mentoring network of Dr. Wagner, and that they will continue in his footsteps. We hope, at the same time, that this reading will inspire those who don't know this or similar mentoring networks to create their own.

Methods

This paper was conceived on the basis of a questionnaire that was sent to Dr. Wagner's mentees and (international) co-mentors as far as the mentoring network could be traced back. The questionnaire consisted of a mentee and a mentor section. Mentees were defined as students or young investigators who did a research project while following a bachelor-, master-, M.D.- or Ph.D.-program, during which they were mentored (co-mentored) by Dr. Wagner. Mentors were defined as academic faculty members who shared the mentoring responsibility for one or more students or young investigators with Dr. Wagner. Addressees who had assumed both roles (initially being mentored by Dr. Wagner, later becoming a local mentor of students and young investigators who were also mentored by Dr. Wagner) were asked to complete both sections of the questionnaire.

Questions to be completed by former mentees of Dr. Wagner addressed their current function and affiliation, the phase of the study during which they were working with Dr. Wagner as a mentor, the university that had granted their degree/diploma, if they stayed for a certain period with Dr. Wagner in Durham, the subject of study, publications resulting from that study, if the cooperation with Dr. Wagner had continued after that training period, and a final question:

> *Describe, within the limits of this compilation (150 words), what you consider typical/relevant/most important to characterize your mentee-experience with Galen as your mentor or co-mentor. General guidelines (don't follow these if you feel different):*
>
> - *Keep it personal, focus on what Galen meant to you*
> - *Feel free (in the spirit of Galen) to write what you think that is appropriate*
> - *Anecdotal information is permitted*
> - *Consider mentioning your current activities/position and, if Galen has been instrumental in your career, consider describing this.*

Questions to be completed by mentors of students and young investigators who had also been mentored by Dr. Wagner were about the number of students/young investigators, the phase of their study during which they were monitored by Dr. Wagner, how many stayed with Dr. Wagner in Durham, research topics, resulting publications, and a final question:

> *Give, within the limits of this compilation (300 words), a description of how the contact between you and Galen came into being, what your common research interests were, where the study data came from, how you interacted with Galen, the way your students interacted with Galen (going to Duke, being co-mentored from a distance, etc.), and what you think is typical/relevant/most important to describe your experience and the experiences of your students with Galen as your colleague and as their mentor. General guidelines (don't follow these if you feel different):*
>
> - *Keep it personal*
> - *Feel free (in the spirit of Galen) to write what you think that is appropriate*
> - *Anecdotal information is permitted*

In addition to the questionnaire, each addressee received a list of all addressees, with the kind request to check it, correct lacking or incorrect contact data, and to signal omissions. Addressees who had not responded received maximally two reminders. There was no further contact with the responders after they had replied, even if the replies were incomplete or creatively edited.

The responses are grouped around the involved centers where the students/young investigators had their home base. Per center, first the local mentor/mentors are mentioned, and then the mentee responses are given. Of every respondent the final free-text question has been cited, verbatim. A few remembrances came to us in a different way, e.g., they were included in other manuscripts for the current commemorative issue of the Journal, where they didn't fit well. We have included these contributions in this paper. In the final free-text question, respondents often used given names; we have not edited these mentioning of persons, because the spontaneous tone of the respondents is part of the way in which they have experienced Dr. Wagner's mentorship. However, in the remaining text of this paper, we used the more formal "Dr. X", etc.

Results

A total of 72 mentees and/or co-mentors of Dr. Wagner received a questionnaire; 45 (62.5%) responded. Homebases of the mentees were, in alphabetical order, Bratislava (SK), Copenhagen (DK), Durham (NC, US), Glasgow (GB), Leiden (NL), Lund (SE), Maastricht (NL), Rotterdam (NL), Stockholm (SE), and Zaragoza (ES).

Locations, mentors, mentees

Bratislava (SK)

Mentor Ljuba Bacharova, M.D., DSc, MBA, senior researcher, and affiliated with the International Laser Center

and the Medical School of the Comenius University, Bratislava, Slovakia, writes:

> *I had the pleasure to share the mentorship with Galen just for a one student — Nina Hakacova. We met her during the first Summer School 2006 in Slovakia. She exhibited an extraordinary interest in research that resulted in her stay in Durham — Galen recognized her talent and strong motivation for research. Direct mentoring by Galen and the abroad experience resulted in Nina's decision to continue her professional career in Sweden, where the conditions for research and for her professional development were incomparably more favorable as compared to Slovakia.*

Mentee Nina Hakacova, M.D., Ph.D., now associate professor and pediatric cardiologist in Lund, writes:

> *One thing that emerges as a principle characteristic of the type of mentoring that Galen did, is mentoring driven by conscious central principle: to stimulate the other's brain so that the person can understand his/her own principles and values, so that the other person can be proactive and take independent decisions in life. Galen stimulated the process of finding out the question to be solved in every person he interacted with and stimulated the process so that the end result would be reached. By having the end in mind, finding methods how to get there, and finally to approach there, confidence is built. He used to tell me, that time is useful when I can think with my own brain. He mentioned how time is needed for thinking. We can't think without time. Easily said, Galens mentoring moved both mentor and mentee progressively on a Maturity Continuum from dependence to interdependence.*

Obviously, the contact between Dr. Hakacova and Dr. Wagner started in the setting of an IRIS [5] summer school. Dr. Hakacova worked for 8 months in Durham. Her Ph.D. thesis focused on a variety of interesting electrocardiographic problems: the ability of mitral papillary muscle positions to explain QRS complex characteristics in humans, right and left ventricular pressure overload as imaged by electrocardiogram, problem-oriented education and cross-cultural collaboration, and electrocardiographic measures of myocardial function and necrosis. Several publications [6–16] witnessed this productive cooperation. After reaching the Ph.D. degree, the contact with Dr. Wagner continued, as a friend and as a co-mentor. See under Lund (SE) for the mentor listing of Dr. Hakacova.

Copenhagen (DK)

Mentor Lia E. Bang, Ph.D., Consultant, Copenhagen University Hospital, The Heart Centre, Dept. of Cardiology, Copenhagen, Denmark, had the pleasure to share the mentorship of Esben Carlsen with Dr. Wagner. Study topics were:

- the evaluation of the ECG-based Selvester QRS score to estimate myocardial infarction size with delayed-enhancement magnetic resonance in patients with ST elevation myocardial infarction treated with primary percutaneous coronary intervention;
- to determine if the baseline QRS morphology was correctly assumed based on an ECG recorded during induced ischemia and if reference to the available baseline ECG altered the designated Sclarovsky–Birnbaum Ischemia Grade; and
- introduction of the myocardial infarction–left ventricular ejection fraction mismatch index based on ECG and comparison of indices based on ECG and cardiac magnetic resonance.

Several publications [17–20] resulted. Dr. Bang writes:

> *I was introduced to Galen through one of his Danish collaborators dr. Peer Grande in 2003 in Copenhagen Denmark. Since then we collaborated on data coming from Copenhagen ST-elevation myocardial infarction treated with primary percutaneous coronary intervention studies especially with different ECG scores and delayed-enhancement magnetic resonance. Since I was introduced to Galen I spent yearly 2–3 weeks in Durham with him. I have enjoyed all the fruitful discussions I had with Galen not only about medicine but also about life in general. We always discussed tutoring and how it could be improved. I still use the tutor methods with great success and Galen is the reason why I enjoy being a tutor. I still remember one of the first wise things Galen told me about tutoring, "You have to be able to enjoy others success to become a good tutor". I also remember all the good times Galen and I spent outside the office, he acting as a tour guide and the humorous glimpse in his eyes when challenging me on a subject. Galen has given me many good advice and taught me a lot through the years about medicine and life in general and by introducing me to a lot of people increased my research network.*

Mentor Peter Clemmensen, M.D., DMSc, FESC, FSCAI, Professor of Cardiology, Associate Professor of Medicine, Chief Physician, Interventional Cardiologist, Department of General and Interventional Cardiology, University Heart Center, Hamburg-Eppendorf, Hamburg, Germany and Department of Medicine, Division of Cardiology, Nykoebing F Hospital, University of Southern Denmark, Odense, Denmark, was initially one of Dr. Wagner's mentees. After that period, Prof. Clemmensen became an inspired mentor of students and young investigators himself. Seven young scientists worked with Dr. Wagner in Durham, most of whom completed a Ph.D. or Doctoral (DMSc) thesis. Subjects were/are: Lene Holmvang: risk stratification in patients with unstable angina pectoris and non-Q wave myocardial infarction; Birgit Jurlander: serum myoglobin and the ECG ST-segment assessing coronary reperfusion status in acute myocardial infarction; Maria Sejersten Ripa: optimizing pre-hospital diagnosis and treatment of acute coronary syndromes; Mikkel Schoss: imaging and biochemical identification of the vulnerable plaque in acute coronary syndrome; Hedvig Andersson:

acute myocardial infarction in patients with normal coronary arteries or minimal atherosclerotic lesions; Yama Fakhri: improving diagnosis and outcomes in ST elevation myocardial infarction and an electrocardiographic scoring system and LVEF function after acute myocardial infarction; Michael Jacobsen: electrocardiographic T-wave morphology in patients with unstable angina — Definition of terms and prognostic implications. A multitude of publications [17,19,21–58] resulted from this extensive cooperation. As a mentee, Dr. Clemmensen was co-mentored by Dr. Peer Grande, M.D., DMSc and Dr. Wagner. During that period, Dr. Clemmensen lived, with his wife, for 2 years in Durham. Since then, uncountable visits over the years followed, either alone or accompanied by colleagues.

Several publications resulted [21,59–74]. Already as a post doc, Dr. Clemmensen and Dr. Wagner started to recruit new talented researchers, many of whom we co-mentored over the next 3 decades leading to many completed Ph.D. and doctoral theses. Dr. Clemmensen and Dr. Wagner also worked on position papers and guidelines together. Dr. Clemmensen writes:

> *Galen was a most generous and analytical mind, and a formidable mentor when I did my thesis work at Duke University. I believe I was the first Research fellow to spend considerable time in North Carolina, and our collaboration continued after we went back to Denmark. Over the years Galen become a better friend than scientific collaborator, although we continued to publish and develop ideas for future research and a better world. Galen managed the emancipation of the "old student" to an independent doctor and scientist with wisdom and humor. Galen's mind worked in mysterious ways, and he would sometimes lapse into philosophy, art and some state that I have not yet figured out. This is probably why in my mind his best (co)mentoring was when collaborating with other senior and more square thinking (forgive me all, but I consider myself included) scientists.*
>
> *When people including myself experienced turmoil in their lives Galen was at his best. His support was enormous and he would always look ahead. Galen's network was enormous and he even remembered names of spouses, children and more remote relatives. He loved when he could put these relationships to work, in an effort to help people.*
>
> *Galen was a great storyteller, and he loved when he could make links from literature, jokes, personal experiences to the present always seeking a new angle or perspective to current challenges.*

Mentee Hedvig Bille Andersson, M.D., now Ph.D.-student and visiting research scholar, Cardiovascular Center, University of Michigan, Ann Arbor, MI, USA, was mentored by Dr. Clemmensen, Dr. Grande and Dr. Wagner. She worked for 3 weeks with Dr. Wagner in Durham, in 2012. The subject researched under the mentorship of Dr. Wagner was the prevalence of acute cardiac disorders in patients with suspected ST-segment elevation myocardial infarction and non-significant coronary artery disease [56]. Dr. Andersson writes:

> *Galen was a big source of inspiration for me in the beginning of my research career. He taught me a great deal about the art of doing research. Most importantly, he taught me the value of collaboration and networking.*

Mentee Esben Carlsen, M.D., Department of Cardiology, Bispebjerg Hospital, Denmark, worked during the bachelor, master and M.D. program (finished in 2015) under the mentorship of Dr. Wagner and Dr. Bang on the electrocardiographic diagnostics in ischemic heart disease. During these educational phases, he stayed 4 times for periods between 2 and 8 weeks in Durham. Five peer-reviewed publications [17–20,75] and a chapter in Mariott's Practical Electrocardiography were the result of this cooperation. Dr. Carlsen writes:

> *My first meeting with Galen was in Copenhagen. I had expected a 5 min meeting with a busy professor. However our meeting turned into an hour long conversation about research. I had no experience with research before the meeting. Galen would slowly guide me, not by giving me the answers, but by asking questions. That meeting sparked our mentor/mentee relation and led to some stays in Durham at Duke and numerous conference/Skype-meetings. Working with Galen in Durham was unique. We would have a meeting at least once a day discussing either specific aspects of the research project or more general discussions. He would read through a draft of the manuscript in the afternoon and give back his comments within a blink of an eye. This close collaboration turbo-charged the research process. Galen mentoring me has given me a toolbox for doing research. And always comes down to: What is the hypothesis?*

Menthee Yama Fakhri, M.D., Department of Cardiology, The Heart Centre, Rigshospitalet, Copenhagen, Denmark and Department of Medicine, Division of Cardiology, Nykøbing F Hospital, Nykøbing F, Denmark, is halfway of a Ph.D. program that runs from 2015 to 2018. His local mentor is Dr. Clemmensen; Dr. Wagner was his external assessor. Dr. Fakhri worked for one week with Dr. Wagner in Durham, had many Skype meetings with him, and had planned another, longer, stay in Durham during this Ph.D. training period. Dr. Fakhri writes:

> *I met Galen for the first time in 2009, where I had just graduated from my bachelors (first 3 years in medical school in Denmark) and just started to work with Peter Clemmensen as a pregraduate research assistant. Galen was at a visit in Denmark. I was invited to be introduced to Galen by Peter. Galen asked me a lot of tough questions about some project that I was going to research on. I had naturally quite limited knowledge in the field, but I tried my best. I think that Galen and I had our first impressions of each other at that time. Next time I met Galen in Durham, it was 4 years after, when I had graduated from medical school and had improved my knowledge, I would say, significantly. I*

knew that Galen was going to ask me a lot of tough questions. Due to the first impression I had from Galen, I was, to be honest, a little bit scared about all those tough questions Galen was going to ask me. However, I was very clear and quite sure that those questions were very important to discuss the answer with Galen. My meeting in Durham was a really fruitful journey, where Galen gave me the most beneficial advice and taught me how to think, how to be curios and passionate as a researcher. One of the days during my stay, we drove to his favorite restaurant and had lunch break. I realized that he was a great person with a great philosophy. Despite his great achievements and unlimited high position in his fields, his thirst for obtaining new knowledge, his humility amazed me. The discussions with Galen in person and via SKYPE meetings were unique with an aha-factor for both of us — as Galen emphasized after every meeting, what he has learned from the meeting.

Mentee Lene Holmvang, now Consultant, DMSci, The Heart Center, Rigshospitalet, Copenhagen, Denmark was during her Ph.D. thesis work mentored by Dr. Grande, Dr. Clemmensen and Dr. Wagner. She spent two periods, of 3 months and 2 weeks, respectively, in Durham to study with Dr. Wagner. Her thesis title was: Early electrocardiographic evaluation of patients with non-ST segment elevation acute coronary syndromes — Implications for prognosis and treatment strategy. Several publications resulted from that period [24–31,33,34,37,76]. Dr. Wagner had the habit to visit Copenhagen on an almost yearly basis, to share ideas and to inspire young researchers. As a consequence, cooperation continued and more publications resulted [17,19,38,44,45,56].

Mentee Birgit Jurlander, M.D., Ph.D., now attending cardiologist at Nordsjællands Hospital, Hillerød, Denmark, was during her Ph.D. thesis program, till 1997, mentored by Dr. Grande, Dr. Clemmensen and Dr. Wagner. She worked several times for one-week periods with Dr. Wagner in Durham. The theme of her study was "Serum myoglobin and the ECG ST-segment assessing coronary reperfusion status in acute myocardial infarction", and several publications were the result [21–23,32,33,38]. The contact with Dr. Wagner continued, personally, socially. Dr. Jurlander writes:

Galen's Way: Multitalented, with sometimes crazy ideas, humble and tolerant, deeply engaged in our research — as well as our lives. I am grateful he visited me in Buffalo, he attended my Ph.D. defense in Copenhagen. We had informal dinners in Durham and at my house, and most recently he visited me for dinner in my new house. Typical for Galen, he wrote me a poem for my Ph.D. thesis defense. It was handwritten, on yellow paper, torn out his notepad. This was Galen's Way – he became a good friend and influenced not only my research – but my life:

Birgit's Wej.
Birgit's Way led past her lander
- *To that place beyond the ocean,*
  Where Buffalo's Bills played near Niagara's flow.
  She played in Florida, California,
- *Atlanta and New Orleans;*
  While Jesper nannied kids and shoveled snow.
  Birgit's Way led through her markers
- *Of the places in the heart,*
  Where sweet -ases, -ponins, -globins move around.
  But there's also ST segments
- *Of those not so sweet ECG's*
  Where she hopes her lack of knowledge won't be found.
  Birgit's way led past her questions
- *That she no kindly asked;*
  With "but Avery", "but Galen", or "but Peer".
  And she always understood that
- *If she didn't like our answers,*
  She could quietly ignore us, and we wouldn't really care.
  Birgit's Way led thru our own hearts
- *And deep into our souls;*
  As we worked and played together all those days.
  Till the Ph.D. was with her,
- *She'd defended her opponents,*
  And a new bridge acrossed the ocean — Birgit's Wej.

Mentee Maria Sejersten Ripa, M.D., DMSc, now cardiologist in the Department of Cardiology, Herlev University Hospital, Herlev, Denmark, did the research in her M.D./Ph.D. program with Dr. Clemmensen and Dr. Wagner as mentors. She worked with Dr. Wagner in Durham during 11 months in 2001, and came back several times thereafter. Subjects of study were the EASI lead system, DANAMI-2 ECG substudies, ECG diagnosis by paramedics, and a Telemedicine study in Greensboro. The thesis was titled "The ECG as decision support in STEMI". Cooperation continued also after the thesis defense, and resulted in a multitude of publications [35,36,39–43,45–53,57,58]. Dr. Sejersten writes:

I had the pleasure of spending a year at Duke Clinical Research Institute (DCRI) with Galen back in 2001 while still in Medical School. I had never done research before and he opened the door to the fascinating world of research for me. He became a devoted and inspiring mentor determined to teach and guide me as I developed my thesis over the next many years. With his continued optimism, sincere spirit and ability to ask all the right questions he was the best mentor I could ever wish for. He made me pursue what I didn't think possible and if it hadn't been for Galen I would never have pursued a fellowship in cardiology like I did. I owe what I have become today to him and will miss his guidance and the great man that he was.

Mentee Rasmus Sejersten Ripa, M.D., DMSc, now at the Department of Clinical Physiology, Nuclear Medicine and PET, Copenhagen University Hospital, Rigshospitalet, Cluster for Molecular Imaging, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark, was also in Durham in 2001. Between 2003 and 2008 seven

publications featuring Dr. Wagner and Dr. Ripa as authors appeared [45,47,49,50,77–79]. He writes:

> *Galen has been a major milestone in my career and life. I spent 4 months at Galen's DCRI lab in 2001 right after finishing my medical degree in Copenhagen. Before that I was not set for cardiology but Galen opened my eyes to cardiovascular clinical research. The stay at Duke was fantastic and very productive. We ended up writing 4 papers in that period and the things Galen taught me about research and the process of writing a manuscript have been an invaluable lesson. Ever since 2001 Galen has been following my research and clinical career with great interest and inspiring comments. Besides being a great mentor Galen was a fantastic person. I will never forget the numerous meetings and dinners with him and Marilyn.*

Durham, NC, USA

Mentor Brett D. Atwater, M.D., Associate Professor of Medicine, Duke University, Assistant Director, Cardiac Electrophysiology, Director, Electrophysiology labs, Durham, co-mentored several medical students together with Dr. Wagner in various subjects: Irene Leeters (Maastricht) [80] investigated the pattern of LV dyssynchrony in patients with right bundle branch block and left anterior fascicular block, Madeleine Turesson (Stockholm) [81] compared conventional and PDF methods of echocardiographic assessment of diastolic function, Bjorn Wieslander (Stockholm) [81] investigated electrocardiographic assessment of LV scar in the presence of left bundle branch block, Sofia Åkerlund (Stockholm) [81] worked on the electrocardiographic assessment of LV scar in the presence of left bundle branch block and the Selvester score, and Markus Hjorth (Stockholm) [82] worked on the MRI assessment of dyssynchrony in right bundle branch block and left anterior fascicular block. Dr. Atwater writes:

> *I sought out a relationship with Galen after reading of our mutual interest in the use of the Selvester score for LV scar in LBBB. I was interested in using the scoring method to predict CRT response and he was happy to mentor me on its use. We found a lot of commonalities in our approach to research and enjoyed co-mentoring several international students. He was instrumental in developing international collaboration on these projects.*

Mentor David Strauss, M.D., Ph.D., Director, Division of Applied Regulatory Science, Senior Advisor, Translational & Experimental Medicine, Office of Clinical Pharmacology | Office of Translational Sciences, Center for Drug Evaluation and Research, US Food and Drug Administration, Silver Spring, MD, USA, started his studies in Durham at Duke university, received the Bachelor degree in 2005, M.D. at the Duke University School of Medicine in 2010 and Ph.D. at Lund University in 2010. Dr. Wagner, Dr. Katherine Wu from Johns Hopkins, and Dr. Hakan Arheden from Lund University were his mentors. Subject of the Ph.D. thesis was: Electrocardiographic imaging of myocardial ischemia, infarction and scar: correlation with SPECT, MRI and arrhythmias. Multiple publications resulted from this **mentee** period [46,83–86] and from the period thereafter [18,54,55,75,87–104], when Dr. Straus continued the cooperation with Dr. Wagner and co-mentored various students with him, including Zak Loring (Durham, M.D. program), Robbert Zusterzeel (Maastricht, Ph.D. program), Bjorn Wieslander (Stockholm, M.D. program), Linus Andersson (Stockholm, M.D. program), Frida Sundh (Stockholm, M.D. program), Jacob Simlund (Stockholm, M.D. program) and Dan Frendl (Durham, Bachelor program), who all worked with Dr. Wagner in Durham. Subjects studied were, among others: cardiac resynchronization therapy and implantable defibrillator risk stratification, QRS scoring quantification of myocardial scar, defining left bundle branch block, drug-induced changes in repolarization. Dr. Strauss writes:

> *I met Galen when I was an undergraduate at Duke University. After meeting with him about the student-run Duke Emergency Medical Services, he emailed the following day asking when he would receive my research study protocol. I was amazed that this senior faculty member in the medical school was taking an interest in me and challenging me to develop my own research project. Under Galen's mentorship, I studied the effect of paramedic activation of the cardiac catheterization laboratory for patients with ST-elevation myocardial infarction. As I continued on to Duke medical school, Galen's mentorship led me to catch the research "bug" coming up with more and more ideas for studies to pursue. When I could not complete them all myself, Galen encouraged me to recruit Duke undergraduates, who I could now mentor in research. I learned from Galen that mentoring has to be unselfish and about self-discovery for the mentee. Galen always wanted to help turn his mentees into what the mentee actually wants. For me, I learned that I loved research and my journey with Galen led me to Europe to obtain a Ph.D. I also discovered that after medical school I did not want to go to residency, but rather pursue a non-traditional path in research. While others advised me strongly to pursue a more traditional clinical training path, through Galen's mentorship I had discovered that I really wanted to pursue a career in research. After graduating, I joined the Food and Drug Administration and Galen and I have continued to co-mentor multiple medical and Ph.D. students. Since meeting him 11 years ago while an undergraduate at Duke, Galen and I have collaborated on numerous projects, co-authored a book, and maintained a close friendship. I greatly miss him and will strive to keep his spirit alive through mentoring.*

Mentor Robbert Zusterzeel, M.D., Ph.D., Staff Fellow Medical Office at US Food and Drug Administration, Silver Spring, MD, mentored together with Dr. Wagner and Prof. Gorgels (Maastricht) two medical students from the Maastricht University Medical School, Laura Hannink (subject: Selvester scoring on patients with transcatheter

aortic valve replacement and left bundle branch block [105]) and Irene Leeters (subject: dyssynchrony in patients with trascatheter valve replacement and left bundle branch block [80]). Before becoming a mentor himself, Dr. Zusterzeel did his Ph.D. studies under the guidance of Prof. Gorgels (Maastricht), Dr. Wagner (Durham) and Dr. Strauss (Durham and Silver Spring). Dr. Zusterzeel writes:

> *I had just finished medical school in 2012 when I started as a research fellow at the FDA, working with David Strauss. David, being mentored by Galen himself, encouraged me to work with Galen on a study about LBBB. Galen could make me feel bad about myself for not thinking thoroughly enough and very accomplished when I had finally figured a problem out, something he called the "treatment". The "treatment" eventually proved to be very effective for learning to conduct research and throughout other hurdles in life. I continued to interact with Galen almost on a weekly basis, either through phone calls or Sunday morning breakfast at Bruegger's Bagels in Durham until his final days.*
>
> *To elaborate on mentoring part specifically, Galen encouraged me to serve as the primary mentor for these 2 students from Maastricht. We would have daily phone calls with the students. Separately, Galen and I would discuss my mentoring and the hurdles I was running into with the students, other mentors or co-authors.*
>
> *Galen not only mentored me, but also taught me how to be a mentor. Galen was a unique personality and a terrific mentor, not only in science but, perhaps, more on life itself.*

Robert M Califf, M.D., now Commissioner of Food and Drugs of the FDA, was, prior to joining the FDA, professor of medicine and vice chancellor for clinical and translational research at Duke University and a nationally and internationally recognized expert in cardiovascular medicine, health outcomes research, healthcare quality, and clinical research. Dr. Califf is a graduate of the Duke University School of Medicine. His bibliography currently comprises of more than 1200 peer-reviewed publications. Several of these are coauthored by Dr. Wagner [106–152]. Initially, Dr. Califf was a **mentee** of Dr. Wagner. Dr. Califf writes:

> *Galen Wagner was a mentor in the truest sense of the term. The mentee always knew that Galen had the mentee's interest as the primary goal and not his own. He was also genuinely interested in the overall well-being of the mentee. That does not mean that his advice was always on target. In fact his ability to view the world from a different perspective always led to deeper understanding of issues and choices, but often I would choose to take a different course from Galen's recommendation. He never took it personally and would always be back the next time.*
>
> *He had a deep commitment to understanding the electrocardiogram as a simple tool that could be used to improve health. His persistent hard work and focus on how the health care system used the ECG to improve decision making were a great model for how a physician investigator can make a difference in the world.*

Mentee Cara Gambill, B.A., P.A.-C., now Physician Assistant at the Hand Surgery Department of Duke Health, was a mentee of Dr. Wagner from 1991 to 1995 after graduating from Duke University with a Bachelor of Arts degree in Public Policy Studies (1991), until she entered the Physician Assistant School at Duke University. She obtained the Master of Health Sciences degree and the Physician Assistant Certification (in 1997). Dr. Wagner was her sole mentor. Under his guidance, she studied T-wave amplitudes in normal populations: variation with electrocardiographic lead, sex, and age [153]. She writes:

> *Under Dr. Wagner's tutelage, I learned how to read EKGs for the GUSTO acute myocardial infarction trials. I was also able to publish an article in the Journal of Electrocardiology and assisted him in the editing of Marriott's Practical Electrocardiography 9th edition published in 1994. I worked with Dr. Wagner for four years after graduating from college and prior to attending school to become a Physician Assistant. Dr. Wagner played an integral role in my acceptance to Physician Assistant school at Duke University. I have now been a Physician Assistant for 18 years, albeit not in cardiology but in orthopedics. Nevertheless, Dr. Wagner nurtured my love of medicine which has persisted far beyond the four years I spent working for him. I will be forever grateful for all he taught me during the time we worked together. He was an amazing teacher.*

Mentee Zak Loring, M.D., now a trainee Cardiovascular Disease at the Duke University School of Medicine, was mentored by Dr. Wagner for seven years. This led to nine authorships, of which one was a first authorship [54,55,88,92–95,103,154]. Dr. Loring writes:

> *I was a second year medical student interested in clinical research when I first met Galen. I had been advised by prior medical students to steer clear of Galen, but decided to meet with him anyway. As Galen picked apart my study proposal and pointed out all its flaws, I understood why people advised me to avoid him. However, I could also tell that there was a lot to learn from him and ultimately found Galen's critiques incredibly helpful in shaping both my development as a researcher and giving me insight into how creative and often non-traditional pathways can lead to wonderful opportunities. His often contrarian voice was invaluable in helping vet ideas and force me to think critically. He remained a mentor to me for the following seven years and his perspective drove me to pursue unique opportunities I otherwise would never have experienced. Galen was a fierce advocate for me and would go well out of his way to help me in any way he could. He was unique and iconoclastic and I will miss him greatly.*

Mentees David Strauss, M.D., Ph.D., Zak Loring, M.D., and Robbert Zusterzeel, M.D., Ph.D., wrote, together:

While Galen's contribution to science and medicine are nothing short of remarkable, his true passion was mentoring. The three of us were extremely fortunate to have been mentored by Galen and had opportunities to discuss the meaning of mentoring with Galen as he reflected on his life during the last months and days. Galen expressed that the most important part of mentoring was to help turn someone into what they actually want and develop self-confidence. The mentee needs to be able to be themselves and make their own mistakes. For the mentor, the process must be unselfish and about self-discovery. For Galen, the key to mentoring was to find someone who cares about being mentored. Galen could be intimidating at first, because he did not want to mentor just anyone; the mentee needed to be committed. When Galen mentored someone, he was "all in". For many mentoring is difficult, but for Galen it was like breathing.

Glasgow (GB)

Mentor Henry Dargie, MBChB, FRCP; now Honorary Senior Research Fellow, Institute of Cardiovascular and Medical Sciences, School of Medicine, University of Glasgow. Cooperation with Dr. Wagner was focusing on the combination of the ECG and cardiac MRI [155–162]. The cradle of the MALT meetings [163] is in Glasgow; the first meeting was held there in 2003. Like the STAFF meetings [163], the MALT meetings, with the typical U-shaped table setting and ample time for intense discussion, have strongly stimulated the international contacts between students and young investigators and senior faculty. Many of the projects that involved international co-mentoring were forged there. Professor Dargie was present when the MALT meeting was born; he writes:

The first MALT meeting was held in the Cardiac Department of the Western Infirmary, Glasgow in 2003, the result of serendipity rather than design. Firstly, a patient, who had sustained a large myocardial infarction, introduced me to a businessman whom he thought might help us buy an MRI scanner costing £2 million for our epidemiology and infarct size research. Listening for only a few minutes he said: 'Would a million pounds help?' At that jaw dropping moment I refrained from saying: 'Yes but 2 would be better'! We raised the rest and began our work on measuring infarct size. Secondly, two of our young researchers visited the core ECG laboratory at the Brigham hospital in Boston with a view to learning more about ECG estimation of infarct size.

Arriving home they recounted their meeting with an interesting cardiologist with the even more interesting name of Galen Wagner who expressed interest in visiting our centre. When Galen arrived we presented our work on the epidemiology of heart failure in which we had used echocardiography and ECGs as our main diagnostic tools and explained we were thinking of using our new MRI scanner on further population studies. He proposed some preliminary studies to 'calibrate' the ECG data with the MRI findings with a view to gaining more diagnostic insights from the ECG which was his main research in Boston.

At that 1st meeting we discussed a wide range of studies involving many other international workers previously known to Galen leading to over 20 potential programmes of work in multiple centres. There was a lengthy and amusing brain storming meeting orchestrated by Galen standing at a flip board enumerating multiple potential studies. A bottle of Malt whisky was to be the prize for the best acronym and, needless to say, Galen won 'hands down' with his idea of linking the acronym to the prize. Thus was the baptism of MALT which was Magnetic Anatomical and eLecTrical studies. We joked that there could never be a more tortured acronym in medical research!

MALT studies continued until now [163]. Galen Wagner inspired interest and joy in equal measure the joint catalysts for which were MALT and Malt.

Mentee Thomas N. Martin, MBChB, now Consultant Cardiologist, Ninewells Hospital, Dundee, Scotland, was during his M.D. program (finished in 2013) mentored by Prof. Dargie and Dr. Wagner. He visited Dr. Wagner in Durham for days and did some work analyzing ECGs with Dr. Selvester. Through Dr. Wagner, Dr. Martin could meet the Duke cardiac MRI unit. Subject of his studies between 2001 and 2004 was the role of cardiac MRI in acute coronary syndromes [157]. Contacts with Dr. Wagner continued, mainly through the annual MALT meetings, and led to further joint studies [155–157,159–162,164–166]. Dr. Martin writes:

We got in contact with Galen after my other co mentor Dr. Bjorn Groenning had a chance meeting with him at a Cardiology meeting. We called him out of the blue in 2002 and in typical Galen fashion he was very warm and welcoming and that was the start of at least 10 year collaboration. We told him we were interested in cardiac MRI in acute coronary syndromes and were looking to collaborate with him from an ECG point of view. He straight away realized that this was fertile research ground and I believe at around the same time he had contact with the University of Lund. We arranged the first MALT meeting in Scotland (Magnetic And eLectical Trials) which had taken place annually ever since. I do not know how he found the time to speak to all of his collaborators, something I can only now begin to appreciate and this is testament to his enthusiasm. I thoroughly enjoyed being taken to watch the Duke University College Basketball match with him.

Mentee Robin A.P. Weir, MBChB (Hons), BSc (Hons), MRCP, M.D., now Consultant Cardiologist, Hairmyres Hospital, Lanarkshire, Scotland, UK, was mentored during his M.D. program, till 2009, by Drs. Wagner, Dargie and McMurray. Subject of study was the pathophysiological role of aldosterone in cardiac remodeling after myocardial infarction [158–162]. Conference calls went on long after completion of M.D., looking at different groups of post-MI

patients and examining cardiac electrical instability based on Holter monitoring, used to devise projects for future BSc students in Glasgow. Dr. Weir writes:

> *I recall my first phone conversation with Galen, in late 2004, his contact details having been passed on to me by a fellow mentee Tom Martin. While I was lucky to have two excellent supervisors in Glasgow – Henry Dargie and John McMurray – I was struck immediately by Galen's unbridled enthusiasm for the project I was devising. He introduced a variety of concepts regarding the electrocardiological side of my study, helping me broaden the horizons of my M.D. and ultimately resulting in an entire chapter of my thesis devoted to the ECG and a number of publications in this field. He asked for nothing in return other than ongoing collaboration, which continued long after completion of my M.D. His singalongs at various MALT meetings, and his hotel lobby gatherings at the AHA will live long in the memory! He truly did fulfil his wish of a University Without Walls.*

Leiden (NL)

Mentor Cees A. Swenne, Ph.D., Associate Professor, Cardiology Department, Leiden University Medical Center, shared with Dr. Wagner the mentorship for two students, only relatively recently. Dr. Swenne writes:

> *Because my original interests had been arrhythmia monitoring, mechanisms of arrhythmias, and later neurocardiology, I knew the scientific network of diagnostic electrocardiology only from a distance. The first time I talked to Galen was somewhere in the course of the Computing in Cardiology conference in Durham, in 2007, where he, as chairman of the local organizing committee, had pushed the CinC Board, the chairpersons and the presenters far out of their comfort zones with a new format for the conference presentations, focused on more time for discussion. Next CinC, in 2008 in Bologna, when the original CinC presentation format was restored, Galen and I walked, with high speed, what we both liked, from the hotel to the remote conference site, and discussed this and much more. During that walk I started to like Galen very much, because he was not only knowledgeable, but had wide interests, original visions and original solutions (although not always practical), and seemed to know exactly what everybody he knew was actually doing. Becoming more and more involved in ECG-oriented research, in the MALT and STAFF meetings, in the Journal of Electrocardiology, and becoming a MALT organizer myself, the contact with Galen intensified and a friendship grew over the years. I am sure that the co-mentoring of (only two) students has changed my insights in mentoring, the most important aspects for me being 1) that mentor and mentee should work hard to find out how the mentee can get as much freedom and as much responsibility as possible: let the mentee discover himself/herself; 2) being a good mentor cannot be a formality but requires genuine interest in the mentee, and, specifically in science, that 3) the rationale of the study (''Why are you doing this?'') remains a prominent question throughout the entire project, from the project plan to the publication. It is difficult to pinpoint why Galen was such a remarkable man and why he was an example and inspirator for many. I think that we can simply accept this fact, without too much analysis, and be grateful for it.*

Mentee Vivian P. Kamphuis, M.D., now Ph.D. Candidate Pediatric Cardiology, Leiden University Medical Center, Leiden, worked with Dr. Wagner during the end of her bachelor's study (2012), before the clinical rotations started. She stayed 4 months in Durham, on a study towards the electrocardiographic detection of right ventricular pressure overload in patients with suspected pulmonary hypertension [167]. Later, in the interim period before her Ph.D. program started, she worked on another study about culprit artery assessment in acute ischemia [168]. She also helped with a chapter in the 12th edition of Marriott's Practical Electrocardiography. Dr. Kamphuis writes:

> *Galen was a unique person with a great passion for research. He was a mentor to whom I could talk about everything from medicine, research, philosophy, literature and arts to the struggles of a medical student and he always had some helpful advice. Galen and Cees were the people who really inspired me to do a Ph.D. and I am glad that I was able to continue to work with both of them even though I chose to go in the direction of Pediatric Cardiology. From going to the MALT meeting every year it is very clear that Galen inspired many people which is a legacy that will continue even though he is not here anymore. I will never forget you, Galen, and when I will be a mentor myself you will be my example.*

Mentee Roderick Treskes, BSc, now a Ph.D. Student in the Cardiology Department, Leiden University Medical Center, Leiden, worked for 3 weeks with Dr. Wagner in Durham, on serial ECG analysis for acute myocardial ischemia detection [169]. He writes:

> *One thing that Galen made me aware of, was the difference between school and real life, something I definitely needed to see. He was very straightforward and helped me to develop as a scientist and as a person.*

Lund (SE)

Mentor Håkan Arheden, M.D., Ph.D., Professor, Department of Clinical Sciences, Clinical Physiology, Lund University, Lund University Hospital, Lund, Sweden mentored 8 students and young investigators together with Dr. Wagner: Jakob Almer and Therese Billgren (Master program), Henrik Engblom (Master program and Ph.D. program), and Martin Ugander, Marcus Carlsson, Erik Hedström, David G Strauss and Joey Ubachs (Ph.D. program) [86,155,170–179]. Of these, Therese Billgren, David G Strauss, Jakob Almer and Joey Ubachs also worked with Dr. Wagner in Durham. Dr. Arheden writes:

> *I came in contact with Galen through Olle Pahlm when I pioneered MRI in acquired heart disease in Sweden 1998*

after having spent two years with Charles B. Higgins at UCSF. Galen was interested in validating ECG measures of infarct size with MRI. We worked with Richard D. White, Cleveland Clinic, on this project with Henrik Engblom and Therese Billgren as students. Later, Galen co-supervised my first four Ph.D. students Marcus Carlsson, Erik Hedström, Henrik Engblom and Martin Ugander. To this end, Lund and Duke had monthly video-conferences as well as visits to Lund by Galen. Later, we also co-supervised Joey Ubachs and David Strauss. Over the years, Galen and I had many conversations on mentorship, leadership, philosophy and life in general, and sometimes we had the pleasure to enjoy these conversations with our wives Marilyn and Kristina. Everybody that spent more than 5 min in the vicinity of Galen knows that his engagement and presence always were intense and he left few indifferent. The idea Galen strongly promoted, a University without Walls, goes back to the days of Socrates. Galen's way of supervising was also very much in the spirit of Socrates. The imprints he made on the society by his scientific contributions were substantial. However, the imprints his spirit made in some of us who worked closely with him were even more important and continues to thrive in us.

Mentor Henrik Engblom, M.D., Ph.D., Associate Professor, specialist in Clinical Physiology, Lund University and Lund University Hospital, mentored 1 Master student and 3 Ph.D. students together with Dr. Wagner. Two of them, Jakob Almer and Joey Ubachs worked in Durham with Dr. Wagner. Jakob worked on QRS-distortion in acute myocardial ischemia (both experimental and clinical studies) [97,170,180], Joey Ubachs on quantification of myocardium at risk in acute coronary occlusion [178,181–183]. Dr. Engblom writes:

As I had the privilege to work with Galen both as a mentee and as co-mentor, I can tell the story of how he walked by my side following my development. He had a strong belief in student's capability to think on their own. One of his missions was to cure students from "studentosis" as he called it. According to Galen this syndrome encompassed symptoms as not think on your own, wait for instructions, sitting at the feet of your master and not dare to make mistakes. By challenging students at different levels of their development to think for themselves he tried to cure this disease. Galen had high credibility and integrity and did never sell out on his core values. We did not always agree. There were times when we had strong, but different opinions on how to proceed in certain situations. It could be quite rough from time to time. But he always respected me for being honest and I always respected him for the same reason. Galen was one of a kind. He had a unique network on which he built his and many others' careers. He fed this network with his eternal flame for research. He was always prepared to discuss the next project, 05:30 in the morning at Grand Hotel in Lund or 01:00 am in a hotel lobby in some small town on the country side outside of Edinburgh; always the same spirit and creativity. He had an endless amount of ideas that could have kept the entire ECG research community active for many years to come. His spirit will live on; his enthusiasm and love for research.

Thank you for letting me borrow you these years. You will always have a special place in my heart. Rest in peace, Galen!

Mentor Nina Hakacova, M.D., Ph.D., Associate Professor, Pediatric cardiologist, Children's Heart Centre, Children's University Hospital, Lund, Sweden co-mentored 2 Ph.D. students with Dr. Wagner, subject of study: papillary muscles: electrophysiology and anatomy [16,184]. Dr. Hakacova writes:

I met Galen at the scientific Summer School in Slovakia and then a year after, I wrote him an email asking if I can come and stay at Duke and do research. After I came back, I co-mentored some students with him and we become friends and cooperated together since then. I did not have any research data with me. He connected me with the pediatric cardiology team at Duke and I collected data that even other students used then. He changed my life and I'm where I am thanks to him. He opened a whole new world for me. He basically lifted me up from the paradigm that since I come from an Eastern Europe country, I'm less than others. He treated me as an equal human being, he did not make any difference. He stimulated my thinking so that I can be confident in what I can.

Mentor Olle Pahlm, M.D., Ph.D., Professor of Clinical Physiology (retired), Lund University co-mentored 9 students with Dr. Wagner, 6 of whom worked also in Durham. Jonas Pettersson (Ph.D. program) worked on high-frequency ECG in ischemic heart disease, Eva Persson (Ph.D. program) worked on studies of ST-segment deviation vs scintigrams in the STAFF III database, Elin Trägårdh (Ph.D. program) worked on high-frequency QRS components and additional leads as adjuncts to the conventional 12-lead ECG, Annika Welinder (Ph.D. program) worked on alternative lead systems for 12-lead electrocardiography, Magnus Nimmermark (M.D. program) worked on exploration of the additive effects of numerical and graphic displays on performance of cardiologists in assessing ECGs from patients with suspected acute coronary syndrome, Anny Lam (M.D. program) worked on a review of the orderly Cabrera sequence for 12-lead ECG, Viktor Elmberg (M.D. program) explored the performance of the Sgarbossa grading system for left bundle-branch block, Mariam al-Mashat and Shahnaz Akil (both Master program) worked on computed electrocardiographic imaging based on ST deviations in the 12-lead ECG [165,185–201]. Dr. Pahlm writes:

I spent the academic year 1988–89 as visiting professor at Wake Forest University in Winston-Salem, NC. Durham and Winston-Salem are well within driving distance, so Galen and I set up regular research meetings. During the summers of 1989 and 1990 I spent several weeks in Galen's home, and we worked

intensely on projects of mutual interest. This laid a firm foundation for continued cooperation which lasted until his death. PubMed lists 87 peer-reviewed papers that we co-authored.

We co-mentored 4 physicians for their M.D. Ph.D. theses, 3 medical students for projects as part of their curricula, and 2 biomedical technologists for their master projects. Several of these students spent time in Durham with Galen. Galen visited Lund multiple times during our cooperation, probably at least 15. Galen showed his dedication to the mentoring process by actually coming to Lund for the Ph.D. thesis defenses, and he wrote and read a poem for each of the graduates at the post-defence parties. His last visit was in 2014 when he was awarded the title "Honorary Doctor of Medicine" by Lund University for his outstanding contributions to research mentoring at the department of clinical physiology.

In the 1990´s Dr. Håkan Arheden started up a new line of research in the department, cardiac MR imaging, and he recruited several medical students to work on research projects required for the M.D. curriculum. Galen and Håkan set up a series of tutorials via video conferencing, following the protocols that Galen had developed together with Dr. Eric Eisenstein. It was astounding to watch Galen's way of "group mentoring" these young students, many whom have become very successful researchers within the field of MR imaging.

I strongly believe that Galen's input into the mentoring process of students in the Dept. of Clinical Physiology has been very important for their professional and personal development. Galen was one of my closest friends and we communicated weekly until his death.

Mentee Mariam Al-Mashat, M.Sc, licensed medical technologist and Ph.D.-student, Lund University, Department of Clinical Sciences Lund, Clinical Physiology, Skåne University Hospital, Lund, Sweden, worked for 2 weeks with Dr. Wagner in Durham. See under Dr. Pahlm for the research subject and publications. She writes:

Olle Pahlm, together with Galen Wagner introduced me to the world of research, and, thanks to them, I'm on the path to reach my goal to reach a Ph.D. degree.

Galen was a great person. He gave everything he had for research and focusing on young people in order for them to learn about research and to reach their goal in this field, without getting/expecting anything in reward. I really respect this quality in him. Galen was a very caring person and taught me to be "specific", in which I'm forever grateful for.

I really wanted to continue my Ph.D. about ECG; in order to keep working with Olle and Galen, but the project that I was offered not about ECG and therefore, I embarked on another path.

I offer my deepest condolences to his family, friends and colleagues who worked/have been working with him.

Mentee Jakob Almer, M.D., physician and part-time Ph.D. student, Department of Clinical physiology and Nuclear medicine, Skåne University Hospital and Lund University, Lund, was mentored by Dr. Wagner during has M.D. program and during his Ph.D. program. He was in Durham for 2 months. See under Dr. Engblom for the research subject and publications. He writes:

During my time working with Galen I experienced some of the hardest moments in my academic career, however, having said that it was also the most enriching period in my life regarding personal, academic and philosophic development. I'm very happy that I had the privilege to undergo Galen's 'school of research', especially at location in Durham with Galen as mentor, chauffeur and friend. He was indeed a unique character, with extremely tough questions and even tougher answers, a sharp analytical mind but also very warmhearted and charming. He will be missed.

Mentee Therese Billgren, M.D., pediatrician, resident in neonatology, Lund University Hospital was mentored by Dr. Wagner during her M.D. program. At that time, Dr. Wagner was the primary mentor; Dr. Billgren also kept contact with primarily Dr. Pahlm in Lund. Dr. Wagner arranged research financing, and this gave Dr. Billgren to be in Durham for about 7 months in the year 2001. Then she returned to Lund (Department of Clinical Physiology), where she continued working with Dr. Wagner (now mainly being mentored by Dr. Pahlm) for another 5 months before returning to Medical School in 2002. Her subject of study was refinement and interobserver agreement of the electrocardiographic Sclarovsky Birnbaum Ischemia grading system. When she returned to medical school she remained in touch with Dr. Wagner during a number of years, while working on her publications [35,40,175–177,179,202]. Thereafter, she continued her training as a doctor and decided to become a neonatologist. Dr. Billgren writes:

Galen has been a great inspiration to me being able to do at least 10 things at the same time!! Working at a manuscript, having a conference call, tutoring a student and taking a NAP at the same time… never loosing track and being able to pick up at exactly the right time even if sleeping for a while!

A lot of students were a little bit afraid of his temper, but the two of us got along splendidly. If I hadn't decided to become a neonatologist I would have loved to continue my work with him—one way or another.

I felt he had a personal mindset I really treasure — he was prestigeless!!

Mentee Henrik Engblom, M.D., Ph.D., Associate Professor, specialist in Clinical Physiology, Lund University and Lund University Hospital, was mentored by Dr. Wagner during his Bachelor-, Master- and Ph.D.-program, and obtained the Ph.D. degree in 2006, after he continued cooperating with Dr. Wagner and became a mentor for other students and young investigators. In Lund, Dr. Arheden was his main mentor and Dr. Pahlm his co-mentor. Title of the thesis was "Quantitative assessment of myocardial infarction — on the relationship between anatomy and electrophysiology

using MRI and ECG"; several publications resulted [155,172–176,179,203]. Dr. Engblom writes:

> *Galen was unique as a mentor. He really believed in me as a mentee at the different stages throughout the years. From the beginning he encouraged me to be critical and think on my own. Early on he told me his own story of "being tired of sitting by the feet of his master"; how he created his own way, which he followed till the end. I thought I knew what that meant then, but I have recently realized that I have not understood it until now, what it means to be an interdependent, thinking, sensing person, not only as a researcher, but as a person. He has played an instrumental role in me continuing with research and becoming an associate professor, mentoring Ph.D.-students myself. Galen cared about the entire me, not only the researcher, but also me as a husband and father. He always cared.*

Mentee Ulrika Pahlm, M.D., now Director of the Emergency Department of Skånes Universitetssjukhus, Lund, Sweden was mentored by Dr. Wagner during her M.D. program [204–207]; she received the M.D. degree in 1999. Dr. Pahlm writes:

> *Galen was my main mentor. I worked with Galen in Durham on several separate occasions beginning in 1994. My first project with Galen took place during the summer break between first and second year of medical school. The project involved studying the relationship between Selvester QRS score and infarct size in patients with multiple infarcts. I had never heard of Selvester score and knew little about myocardial infarction but Galen believed in me and he helped me believe in myself. During my time with Galen I learned a lot about research, life and myself. Galen was incredibly generous with his time and introduced me to several amazing people including Dr. Selvester and Dr. Eugene Stead. He inspired me to continue to do research and to follow my own path. We stayed in touch over the years, and I consider Galen to be one of my closest friends.*

Mentee Eva Persson, M.D. Ph.D., Department of Clinical Physiology and Nuclear medicine, Lund University Hospital, Lund, Sweden was mentored by Dr. Wagner during her Ph.D. program. She worked for 2 weeks with Dr. Wagner in Durham. See under mentor Dr. Pahlm for the research subject and publications.

Mentee Jonas Pettersson, M.D., Ph.D., International Medical Director, Novo Nordisk A/S, Denmark was mentored by Dr. Wagner during his Ph.D. program (Lund University, 2000). He was based in Lund but visited Durham several times between 1993 and 1998, to spend there approximately 6 months in total with Dr. Wagner. See under Dr. Pahlm for the research subject and publications. The collaboration continued for many years even after completion of the Ph.D., and several additional papers were published, mainly on the subject of high-frequency ECG [39,48,188–194,196–198,200,206,208–210]. Dr. Pettersson writes:

> *Galen meant a lot to me, both as a research colleague and a family friend. He was an extremely inspiring person with a lot of energy and ideas. Nothing was impossible in his world. His dedication was overwhelming and contagious. He inspired everyone around him and it was always a true pleasure to work together. He shared his huge experience from decades of research with everyone including the youngest student with equal enthusiasm. At the same time, he was always open to new ideas and was never judgmental in his demeanor. He was respectful to all and welcomed everyone in the same manner irrespective of their seniority.*
>
> *Although we were different personalities, Galen left an everlasting impression on me. He provided me with tools which I implement in my everyday life.*

Mentee Michael Ringborn, M.D., Ph.D., Specialist in Internal Medicine and Cardiology, Consultant in Cardiology, Thoracic Center, Karlskrona, Sweden was mentored by Dr. Wagner from 1995 to 2013 during his M.D. and Ph.D. research (with an interruption, during which clinical work prevailed). In 2013 he defended his doctoral thesis "Ventricular Depolarization in Ischemic Heart Disease: Value of Electrocardiography in Assessment of Severity and Extent of Acute Myocardial Ischemia". Dr. Ringborn writes:

> *I clearly remember my first contact with Galen Wagner. It was in July 1995 and I had just finished the first half of medical school in Sweden. I'd been offered an American Heart Association scholarship for a year at Duke University to collect data for a study, got permission for a one year leave from medical school and had this initial telephone call with a man that would come to make a significant difference in my life.*
>
> *That telephone call was the start of a long and fruitful learning experience for me in many ways, not only in cardiology research. I immediately noticed his very unique personality in general and as a research mentor in particular. His enthusiasm in mentoring a young, inexperienced medical student in the research field of cardiology was striking. His never-ending energy to come up with new ideas, new ways to look at things, new suggestions of collaborations, new possibilities of collecting data, using other, already existing databases etc. was impressive. His office was always open for any medical student who was interested and curious about learning cardiology research. In a conversation with Galen Wagner you never knew where it would lead. Our countless discussions over the years always opened my mind and boosted it with energy and several new inputs that I later could digest and use to form new directions in solving specific problems, push forward ongoing as well as planning new projects.*
>
> *During my year in the US we collected a database (STAFF III) that has later come to play an important role both to me and numerous younger as well as more experienced medical and engineering researchers, as*

Galen built an invitational Symposium initially based on it. This "STAFF Symposium" has since then been held every year or every other year in several different countries for two decades [163].

Galen had an outstanding sense of networking. Not only for himself, since one of his signum was to be unusually modest in focusing on his own success and accomplishments. Rather, he played a role as a facilitator, using his great network connecting other people. In his very informal way he thereby easily introduced me as well as all other students he mentored to a vast variety of experienced researchers around the world. In every sort of discussion he always took the opportunity to include you to get you involved, being just a telephone conference, informal chat in the corridor or a larger discussion at a meeting. By this manner I early became introduced to his concept of "university without walls", through which he has contributed to so many fruitful and successful collaborations in the field of cardiology research. In the several "STAFF Symposia" he always kept a central role in both the planning, invitations and he highly enriched so many discussions during the sessions. In every situation he became a natural, informal leader challenging our mind and gently pushing his open minded concept forward.

He not only opened the barriers between our "walled (physical) universities", but also facilitated the very important collaboration between biomedical engineers and clinicians in the field of cardiology research.

Although I after graduation from medical school pursued a career as a clinical cardiologist with modest research activities, we still kept regular contact. This was tuned up again later when I decided to do my Ph.D. During the years Galen became a very valuable and loyal friend of mine. He was always there as a support whenever you needed him, with full respect of the decisions you made in life, even though he could give some challenging questions now and then to test your future goals. During the 21 years I had the privilege of knowing Galen Wagner he has been a role model in several aspects. I feel confident being only one of so many medical students he has supported during these years and many years before me.

The world has lost a great man and the scientific community has lost an extraordinary mentor. In his memory though there are so many he has inspired through his work, and let us hope that we all can try to continue in his spirit.

Mentee Elin Trägårdh, M.D., Ph.D., associate professor. Specialist in Medical Radiology and Nuclear Medicine at Skåne University Hospital, Malmö, Sweden, was co-supervised by Dr. Wagner during her Ph.D. program (2001–2007). Dr. Pahlm and Dr. Pettersson were co-supervisors in Lund. Subject of the thesis was the high-frequency ECG and the value of additional leads. Including the papers that appeared after the thesis, a total of 8 peer-reviewed papers were published [12,97,194–198,211]. Dr. Trägårdh writes:

Galen was always enthusiastic and encouraging, even when I was a medical student trying to put together some ECG research in parallel to other courses at medical school. It was a great mentor to have as a young student and he was also very encouraging when I was a more senior scientist, having medical students and Ph.D. students of my own.

Mentee Martin Ugander, M.D., Ph.D., Associate Professor, Department of Clinical Physiology, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden was co-mentored by Dr. Wagner in the first year of the Ph.D. program (defense of the thesis "The relationship between regional myocardial wall thickening and infarct transmurality assessed by MRI" was in 2006). Dr. Arheden was the main mentor of this Ph.D. work in Lund. Here, the value of the initial contact with Dr. Wagner is to be found in what happened later, when it transitioned into a role where Dr. Ugander co-mentored with Dr. Wagner after having started a faculty position several years later at Karolinska (see heading "Stockholm").

Maastricht (NL)

Mentor Anton P.M. Gorgels, M.D., Ph.D., Em. professor of cardiology, Department of Cardiology, Maastricht University Medical Centre, Maastricht, The Netherlands, co-mentored 23 of his students (Master program) with Dr. Wagner, of whom 20 worked with Dr. Wagner in Durham. Major research themes were reperfusion arrhythmias, and the ECG in acute cardiac ischemia [80,105,154,164,178,212–226]. The Maastricht group has described the "Duke–Maastricht Bridge" in a separate paper [227]. The reader is strongly encouraged to read this paper, because it has worked out systematically the various aspects of Dr. Wagner's mentoring style, something that has not been done here, where free-text answers of those who responded prevail, and the total image remains incomplete because the mentoring network has only partly been explored, and only roughly 2/3 of the addressees have responded. Prof. Gorgels writes:

Galen's primary interest was electrocardiology but with the advent of new imaging techniques, he recognized new opportunities to improve the ECG as a diagnostic tool by using information from (multimodal) imaging techniques. Galen liked to collaborate with likeminded researchers and much effort was spent not only to build solid collaborations, but also establishing a background to train students to do research in a transnational environment. Thus walls between universities were broken down and bridges were built to establish bilateral collaborations and exchange programs. This is what Galen called the "university without walls".

The story of our collaboration named "the Maastricht–Duke-bridge" started in 2003 when Mitch Krukoff, at DCRI, and me wanted to test the hypothesis

that reperfusion arrhythmias were a sign of larger infarct size. Having been trained by Galen himself, Mitch found in Galen an excellent potential mentor for students to be coached in designing and performing their authentic scientific projects. Maastricht students were stimulated to go to DCRI in Durham [NC) and spend research time using the available ambulatory ECG databases under local supervision of Galen and Mitch. Subsequently, this program was continued by Ph.D. fellows, but Galen wanted to continue research electives at the student level. A specific need emerged for a training program to teach students how to do their own research using databases for which they had to build their own scientific collaborations.

Unique aspects of the program were that the student acted as the principle investigator, being responsible for finding a database, designing the study protocol, bringing together co-investigators, gathering and analyzing the data and preparing a manuscript ready for submission. Also students got the opportunity to present study proposals and/or results at scientific meetings such as the MALT meeting.

The program has then continued until 2015.

It was a privilege to work with Galen at the mentoring and scientific level. He was a mentors mentor and his qualities were acknowledged by the Maastricht University by granting him with an international mentor award.

Mentee Daniel A. Geerse, M.D., internist-nephrologist, Bravis Hospital, Roosendaal, The Netherlands, worked for 12 weeks in Durham during his research project in the course of the M.D. program (2006). Mentor in Maastricht was Prof. Gorgels. Subject of the study was "Comparison between contrast-enhanced magnetic resonance imaging and Selvester QRS scoring system in estimating changes in infarct size between the acute and chronic phases of myocardial infarction [214]." Dr. Geerse writes:

Galen was a very enthusiastic mentor. He primarily taught me that every relevant research question can be proposed. He was very helpful in gathering the data we needed for our research. We even went to the Johns Hopkins after he scheduled an appointment there with some co-researchers.

Mentee Stephanie Knippenberg, M.D., Ph.D., Neurologist in training, Zuyderland Medical Center, Heerlen, the Netherlands, was 4 months in Durham in the course of research in the course of her M.D. program (2007). In addition to Dr. Wagner, she was monitored by Prof. Gorgels at the home base, and Dr. Engblom in Lund. Subject of the study was "Selvester QRS score and infarct size by cardiac MRI", resulting in 2 publications [178,215]. Dr. Knippenberg writes:

Galen Wagner was a great man, of who I think is responsible of me ending up in a research project. Before I went to Durham, research was completely new to me. In those 4 months I was in Durham, he guided me through the ins and outs of research. It inspired me to do a Ph.D.-project, although it was eventually in neurology. I remember Galen as a real teacher and a hard worker. But also a caring person, taking all the students out for a lunch or dinner, driving in his white old Volvo filled with literature.

Mentee Irene E.G. van Hellemond, M.D., Residency in Internal medicine, Catharina Ziekenhuis Eindhoven and Ph.D. student at the Department of Medical Oncology at the Maastricht University Medical Center (MUMC+) worked also on her science project in the M.D. program. Prof. Gorgels and Dr. Wagner were her supervisors. She worked for 6 months in Durham. Subjects of study were the relationship between the initial ST segment deviation toward and the final QRS complex deviation away from the posterolateral wall in acute inferior myocardial infarction, consideration of the QRS complex in addition to ST segment abnormalities in the estimation of the 'risk region' during myocardial infarction, and the stability of the ST segment estimation of myocardial area at risk between the pre-hospital and hospital ECGs in patients with ST elevation myocardial infarction [212,213,223,224]. Cooperation with Dr. Wagner was later continued by interacting with new students to further explore the theories developed with Dr. Wagner. Dr. Van Hellemond writes:

A mentor was very important during the period I was in Durham. I believe that if I had chosen another project with a mentor less motivated and interested in my personal life, I would not enjoy research as much as I do now. Galen taught us to be critical before you start a project and to start something only if it has your interest, instead of doing what somebody else wants you to do. The end result will be better if there is a strong inner motivation. I am absolutely sure that the research experience I obtained in Durham, helped me during the applications for my current positions as a resident in internal medicine and as a Ph.D. student in the field of Medical Oncology.

Rotterdam (NL)

Mentee Jonathan Lipton, M.D., Ph.D., now Cardiologist/Electrophysiologist, Royal Hobart Hospital, Hobart 7000 TAS, Australia, was mentored by Dr. Wagner during his M.D. program, and later during his Ph.D. program. During the M.D. program (graduation 2003), when Dr. Lipton was a medical student in Leiden, Dr. Wagner was his sole coach. During the Ph.D. program (thesis defense 2010), Dr. Lipton was in Rotterdam, and was coached there by Prof. Maarten Simoons. Dr. Lipton stayed 6 months in Durham with Dr. Wagner. Research projects were:

- pre-hospital transmission of ECG from ambulance to cardiologist cell phone (the 'TIME' study) [36,42,46];
- use of high frequency QRS analysis during exercise testing to detect ischemia [228,229];

- comprehensive care improvement initiatives to shorten door to balloon time in patients with acute myocardial infarction [230].

Dr. Wagner introduced Dr. Lipton also to the IRIS international Research Interdisciplinary School initiative [4], where he, after initial participation, was invited to serve as a faculty member. Dr. Lipton writes:

> *Galen accepted me for a research elective without knowing who I was and what my capabilities were. He personally picked me up from the Durham airport where I arrived in 1999 as a young medical student from the Netherlands with no research experience. On the ride back he started asking me questions "Why did you come here?" "What do you want to do?" "How are you going to do this?" Before I knew it I was coordinating a prehospital ECG transmission project, feeling very much out of my comfort zone and learning more than I ever had during my previous studies. This research elective formed a pivotal point in my own career. Galen taught me how to approach complex problems/projects and find ways to achieve the goal, while never losing sight of that goal. I learned how to use these skills to approach goals in research, clinical work, career and personal life.*
>
> *The initial experience led me to pursue a career in cardiology in Rotterdam, obtain a Ph.D. including spending a year for research in West Virginia and subsequently a clinical fellowship in electrophysiology in Sydney and Melbourne. He was always available in person at conferences or via Skype to discuss career decisions and/or research ideas.*
>
> *My last interaction was talking about the challenges of setting up a treatment center for arrhythmias in Hobart, Tasmania; and he was asking me the same "Why, What and How" questions, making sure the goal was clear and the steps to achieve it well thought through.*
>
> *Galen's brilliance in mentoring and teaching combined with the vision of a "university without walls" have made a lasting impression on all those he has worked with. During my research I participated in the IRIS program and was fascinated by the methodology and group dynamics. I am honored to have been selected as a faculty member and always look forward to the IRIS, where I feel the transfer of his ideas and methodology for teaching and research is especially strong.*
>
> *He was a great person. Enthusiasm, curiosity and unfathomable intellect are just some of the terms to describe him. I recall him, on more than one occasion, dozing during a research presentation only to wake up and startle the presenter by asking the critical question in a thundering voice. I'm sure that if at all possible, he will find a way to continue to do so in the future!*

Mentee Stefan Nelwan, Ph.D., Head of the Department of Medical Technology, Erasmus Medical Center, Rotterdam, The Netherlands, was co-mentored by Dr. Wagner during his Ph.D. program period (2000–2005) [231–234]. He worked for a number of short periods with Dr. Wagner in Durham. Dr. Nelwan writes:

> *Galen's network reached out to the Netherlands as well. In the nineties the Thoraxcenter of the Erasmus Medical Center in Rotterdam and Duke University were participating in large clinical trials where dynamic ECG changes were studied. Mitch Krucoff and Galen soon collaborated with Arthur Maas and Rolf Veldkamp while working towards a Ph.D. supervised by Maarten Simoons. Faculty and staff were also involved (Peter Klootwijk and Simon Meij). Galen continued to work with Maarten Simoons and Simon Meij to study reduced ECG lead systems in the context of acute cardiology. They supervised my Ph.D., starting in 2000 and finishing with my Ph.D.-defense in 2005.*
>
> *Galen was an enormous supporter during my doctoral work. We would have many conference calls and face to face meetings together with other students. As a mentor, Galen asked the right questions to help you in the right direction. Where possible he would let you take new steps and responsibilities. I was privileged to act as peer reviewer, assist with and write editorials for the Journal of Electrocardiology. More importantly, Galen was the initiator of 3 "Glider" conferences. Glider initially was set up as a special symposium after my Ph.D.-defense in November 2005 and was named after the cities from which the international participants were coming (Glasgow, Lund, Durham and Rotterdam). Galen associated Glider with the WWII-museum near Arnhem where a number of gliders landed during the allied operation Market Garden.*
>
> *The legacy of Galen for me is that Galen truly implemented the vision of a university without walls, originally started by Galen's mentor Dr. Eugene Stead. But Galen improved this by realizing it is about people collaborating. He generously shared ideas, data and contacts in order to have people work together. This had a reciprocal effect. Because of his presence and personality he was able to have people communicate ideas and work on hypothesis together in early stages. It is not something that can be copied easily, but I definitely will try.*

Mentee Rolf F. Veldkamp, M.D., Ph.D., Cardiologist, The Hague Medical Center (HMC), The Hague was co-mentored by Dr. Wagner during his Ph.D. program (the thesis was defended in 1995). Co-mentors were Prof. Maarten L. Simoons, Dr. Mitchell W. Krucoff and Dr. Robert M. Califf. Dr. Veldkamp worked with Dr. Wagner in Durham from January 1991 through June 1993. Research topic was continuous digital 12 lead ST-segment monitoring in acute myocardial infarction [120,123,235,236]. Dr. Veldkamp writes:

> *Mentors tend to tell you what to do, give a direction of thought. Galen was different. He probed you for what you knew, your thoughts, questions, remarks. This resulted in solid reasoning and better understanding of the subject.*

He did this with warm interest in your background and circumstances. Coming from the Netherlands days before the gulf war started made me being quite alone. Me and my wife could not afford the high prices for trans-Atlantic flights anymore. When my Duke research fellowship was prolonged to 2.5 years she came over to stay for the remainder of the time. Galen made her his editorial assistant for the 9th edition of Marriot's Practical Electrocardiography, so she could afford to follow courses at Law-school and stay with me.

Being a mentor myself I have tried to keep Galen's mentoring style in mind. Coaching by asking keeps the mentee concerned, interested, responsible.

Stockholm (SE)

Mentor Martin Ugander, M.D., Ph.D., Associate Professor, Department of Clinical Physiology, Karolinska Institutet and Karolinska University Hospital, Stockholm, Sweden co-mentored 8 students with Dr. Wagner: Björn Wieslander, Linus Andersson, Siri Sjöberg, Sofia Åkerlund, Madeleine Turesson, Frida Sundh, Jacob Simlund, Markus Hjorth, who worked on topics revolving around the ECG and MRI, left bundle branch block, scarring and diastolic function. The titles of the most relevant publications are:

- Evaluation of Selvester QRS score for use in presence of conduction abnormalities in a broad population [237].
- Left ventricular mechanical dyssynchrony by cardiac magnetic resonance is greater in patients with strict vs nonstrict electrocardiogram criteria for left bundle-branch block [54].
- Incidence of strict versus nonstrict left bundle branch block after transcatheter aortic valve replacement [100].
- Selvester QRS scoring in conduction abnormalities: Caution recommended due to recent findings [238].
- Specificity for each of the 46 criteria of the Selvester QRS score for electrocardiographic myocardial scar sizing in left bundle branch block [81].
- Selvester scoring in patients with strict LBBB using the QUARESS software [102].
- The relationship between electrocardiographic left ventricular hypertrophy criteria and echocardiographic mass in patients undergoing transcatheter aortic valve replacement [239].
- Investigation of potential mechanisms of sex differences in quinidine-induced torsade de pointes risk [101].
- Impact of ostium secundum atrial septal defect closure on the resolution of falsely positive electrocardiographic criteria for myocardial scarring [75].
- Localization of myocardial scar in patients with cardiomyopathy and left bundle branch block using electrocardiographic Selvester QRS scoring [55].

Dr. Ugander writes:
"Galen" is literally the Swedish word for crazy. Galen was crazy, in very much the positive and at times even the less positive sense of the word. I am the first to profess my respect and both deep appreciation and thanks for 16 wonderful years of first being inspired and mentored by, and subsequently working closely, collaborating, co-mentoring with and befriending Galen Wagner. He was crazy enough to have talent for approaching the novice investigator with unbridled curiosity and enthusiasm while keeping a laser focus on ensuring project completion. The fruits of his commitment and love for science and fostering the next generation of scientists can been seen in the amazing results he achieved both with regards to publications and the subsequent successful careers of those he has worked with. In fairness, he also had bad temper at times, and could get quite upset at the young investigator that didn't live up to his high expectations. That said, as frustrating as this could be to see, it particularly impressed me that once the heat of the moment had subsided, he could speak freely and humbly about his own personal shortcomings and ambitions to evolve his communication skills. It warmed to witness him constantly adapt his communication style and improve as a person up to the end of his life. My impression is that this quality is rare among individuals of all ages, not to mention senior experts in their fields. I am forever indebted to Galen for the inspiring times we spent together and I am confident that his legacy will continue to serve as a beacon of guidance in the continued evolution of science and scientific training as we move forward.

Mentee Linus Andersson, M.D., intern at Södersjukhuset in Stockholm, was co-mentored by Dr. Wagner during the master thesis project and during the fourth year of the M.D. program. In 2012, he worked for five months in Durham with Dr. Wagner. In Stockholm he was mentored by Dr. Ugander. For the research subject, see under Dr. Ugander. Dr. Andersson writes:

The things that characterize Galen when it comes to mentoring is for me two things. 1: It was impossible to ask a question and get a straight answer. Galen answered my question with lots of other questions until I, by myself, had answered my own question. This led to a greater understanding of the problem I was trying to solve and it made me realize that I knew more than I thought. 2: Even though I was inexperienced and never had done research before, Galen made me feel that my opinions and reflections were not only relevant but important.

Mentee Jacob Simlund, M.D., junior physician at Capio St Görans Hospital, Stockholm, Sweden was mentored by Dr. Wagner during his M.D. program. He worked for 6 months in Durham with Dr. Wagner, and was mentored in Stockholm by Dr. Ugander. For the research subject, see under Dr. Ugander. Dr. Simlund writes:

Galen had the ability to detect when I didn't fully understand the subject we were discussing, and he asked questions until I was forced to admit that I couldn't answer. One time in the library in Galens

office, when I was completely out of answers, Galen asked me if I knew what was missing in my draft. I had no clue. He took my draft and wrote with capital letters: "JACOBS BRAIN". At the time it felt a bit harsh, but I still have the draft at home as a reminder to understand and not only memorize what I have in front of me.

Mentee Björn Wieslander, M.D., Ph.D., now researcher in Karolinska CMR group led by Dr. Ugander and physician at the Department of Clinical Physiology, Karolinska University Hospital was mentored by Dr. Wagner during his master and Ph.D. studies. He was co-mentored by Dr. Ugander and by Dr. Strauss at the US FDA. See under Dr. Ugander for the research topics. The cooperation with Dr. Wagner was continued as a co-mentor for the Karolinska Master student Sofia Åkerlund in 2015. Dr. Wieslander writes:

Galen's mentoring style was highly focused on development of his students through deep personal engagement. In his own words over the phone from his hospice bed "the word mentoring doesn't really do the process justice". Although most of my initial research experience was fun, I sometimes found it unsettling that Galen simply would not allow anything but rapid development. He had a particular way of kindly and encouragingly guiding novices in the new world of science, generously sharing his time, energy, insights and vast network while holding students to a high standard of personal conduct. He was never afraid to provide clear and prompt feedback, positive and negative, even when it resulted in frustration for both parties in the short term. I attribute this to his persistent focus on the long-term good of the student, a singularly positive mentor trait that I believe Galen possessed to a unique degree.

Mentee Markus Hjorth, now a medical student at Karolinska Institutet was mentored by Dr. Wagner during the fourth year of the M.D. program; graduation will be in January 2017. At the home base in Stockholm he was mentored by Dr. Ugander and Dr. Wieslander. Markus Hjorth worked during six months in Durham with Dr. Wagner, during the last months of his life. Subjects of his (not yet published) research were:

- distribution of QRS axis in right bundle branch block: defining the QRS axis range of right bundle branch block combined with left anterior fascicular block in the era of cardiac resynchronization therapy
- the relationship between strictly defined RBBB LAFB and infero-anterior left ventricular wall dyssynchrony

Markus writes:

I've never had a mentor like Galen before
It's hard to digest that he's not here anymore
Unlike other mentors he let the student decide
He never cared about money nor pride
Galen was curious and driven by his genuine interest
He was highly intelligent and at the same time very modest
He had a huge love for both his work and his wife
He helped me to figure out what I want to do in life
Galen forced me to think about what I wanted to be
He taught me about a lot more than the ECG
Although I only knew him for half a year
I get tearful of the thought that he's not here
I'm blessed to have been Galen's mentee
And his spirit will always be with me

Zaragoza (ES)

Mentor Pablo Laguna, Ph.D., full professor on Signal Processing, Department of Electronic Engineering Zaragoza University, Zaragoza, Spain shared the mentorship of four students/young investigators with Dr. Wagner. Subjects of study revolved mainly around ischemia detection and quantification form the ECG and its correlates with ischemia extension, severity and occluded artery [240–243]. Prof. Laguna writes:

I happened to know Galen at the Lund Computers in Cardiology meeting in 1997. Since then, it was always obvious to me he had a terrific engine, using one of his favorite adjectives. The initial meeting for STAFF III studies was an extraordinary example of how to push ahead initiatives, even if the path ahead was far from clear, just having the clear conviction the path was somewhere there.

We face the challenge to extract, from the ECG, some indexes to improve the sensitivity/specificity of the classic ST level for Ischemia characterization. We start speaking about the Karhunen–Loève transform that for him was not very familiar. However, rather than use some "a priori" reluctance that one could have expected, he was excited about to know why we did think that tool could add. Later, Galen's clinical input was determinant to better frame the observations derived from this tool both by e-mail and at several STAFF meeting.

There are some features in Galen's personality worth to mention as a tribute to his memory. Galen was very good in turning off the mechanism of "a priori" bias, and his perception about someone he met for the first time was always positive, allowing people to show with facts the extent of their ideas, projects, initiatives, etc. To materialize those principles he worked hard in his "University without walls" life project, that he instilled in us all.

Galen was very good in looking for paths different from those already explored, avoiding the inertia of the well-established and well-trodden routes. This search, at times ended in closed roads, but other times opened new routes to unexplored destinations, and Galen knew this is the price to pay to arrive to new destinations.

Mentee José García Moros, Ph.D., Professor at University of Zaragoza, Institute of Engineering Research of Aragon, Department of Electronics and Communications Engineering, Engineering at the Engineering and Architecture School (EINA), Zaragoza was co-mentored by Dr. Wagner during his Ph.D. project (thesis 1998). Supervisor in Zaragoza was Prof.

Laguna. Subject of the study was ischemia monitoring and detection based on the use of Karhunen–Loève transform applied to the ECG. Dr. Garcia writes:

> *I remember Galen as a very enthusiastic person, always available to discuss ideas and propose future research challenges. It was always a pleasure for me to discuss about my research with him together with my advisor Pablo Laguna, and with the other researchers involved during my Ph.D. work, including Leif Sörnmo and Paul Lander. I especially remember our long conference calls for discussing the advances of my work and journal papers related to the analysis of PTCA ECG recordings and also the meetings in the hotel lobbies during several conferences when we met personally. It was a great honor for me to collaborate and learn from him.*

Mentee Esther Pueyo, Ph.D., Associate Professor on Signal Processing, Aragon Institute for Engineering Research, University of Zaragoza, Zaragoza, Spain was mentored by Dr. Wagner during her Ph.D. program (thesis 2006). Her mentor in Zaragoza was Prof. Laguna. Subject of her study was characterization of depolarization and repolarization ECG changes during acute myocardial ischemia. Two publications resulted [243,244]. After the Ph.D. cooperation with Dr. Wagner and other researchers continued, which led to one additional publication [96]. Dr. Pueyo writes:

> *I met Galen at the 4th STAFF Studies Symposium held in Wagenigen, Holland, in 2002. I was impressed by the knowledge and enthusiasm shown by Galen during the whole symposium. His input to each of the studies presented during the meeting was extraordinary. When I presented the work I had developed under the supervision of Pablo Laguna at the University of Zaragoza, Galen got immediately involved and willing to participate. This represented a major opportunity for me to collaborate with expert cardiologists like Galen and others who were already working with him, like Michael Ringborn and Olle Pahlm. This developed into a fruitful collaboration in which Galen was always present in one way or another. Subsequent STAFF Studies Symposiums allowed me to get to know Galen better and appreciate even more his superb personality. We will all miss him and will remember him with love and fondness.*

Limitations and discussion

The entire monitoring network could not be contacted, and only part of those who received the questionnaire provided answers. This may have biased the current overview. Moreover, the methods used to conceive this paper do not allow firm conclusions based on objective information and a quantitative approach. This is inherent to the matter under discussion.

We hope that, in spite of these limitations, this paper has a value for the reader. The paper is meant to stimulate thinking about international mentoring as a means to achieve important learning experiences and personal development of young investigators, to intensify international scientific cooperation, and to stimulate scientific production. International mentoring may not be confounded with international exchange programs or with students who perform part of their study at another university. With international mentoring, students are involved in international cooperative science projects, which strongly train them in collective, cooperational aspects, rather than pursuing a pure personal goal. It helps the young investigators to prepare for their professional career, and to develop skills and insights that usually can only be attained later, depending the development of their career. Dr. Wagner gave us a great example!

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