Integrated Physician/Health Care Provider Medical Instrumentation with documentary Personal Computer based EML with concomitant Wireless and Cell Phone Capability

**Significance**: The advent of wireless and cellular coverage has provided new tools to leverage the computerization of healthcare processes, particularly improved method of collecting data from patients, accurate documentation of physical examination findings. An instrument is needed that utilizes these capabilities and fits well within the human interactions and conversations that form the basis of healthcare. Most of the current desktop and tablet-type information systems used in healthcare are awkward. The device must integrate well into the flow of the physician/patient encounter as well be ergonomically correct and graceful. Moreover, a highly usable PC based physician / nurses toolkit would greatly leverage the electronic medical record and a convenient portal for telemedicine applications. The telemedicine aspect of device could bridge barriers in communication by accessing interpreters and appropriate language forms directly to the provider patient interaction.

The dimensions of the machine must be that of a typical clipboard and be thin and lightweight. Additionally, the backside of the machine must have a molded contour to carry various wireless pieces of medical instrumentation such as ophthalmoscope, otoscope, thermometer, wireless stethoscope, etc. Within these moldings would also be recharge packs for recharging these various instruments when not in use. Additional provisions will be made for ultrasound which may not be able to fit into a wireless format because of power requirements. (This needs to be studied.)

In addition, there needs to be a camera and microphone to do documentation. The camera should be integrated and have both macro-photography and variable lens capability.

**Wireless capability/Wireless cards**: The computer must accommodate the instrumentation noted above as well as be able to integrate into LAN networks. Additional ability to integrate into cellular networks for telemedicine applications is needed. There should be a Bluetooth capability for headset to the provider as well.

**Durability**: The tablet must be able to withstand the abuse typical in the medical environment. It must be hardened with high-impact plastic and a deformable plastic ring around the perimeter to soften blows on dropping as well as to give some protection to the glass screen. A “shock-key” type disc system could also be employed for the hard drive. Alternatively, the wireless system could be used to access hard drives that are remote to the PC and contained in a building server unit.

**Screen specifications**: The screen should be wide enough as to form a page similar to an 11 x 8 inch page which the user can work on. It should be backlit and support fairly high definition graphics. The screen itself should have touch sensing so that a stylus or finger can be used to check and uncheck boxes. A colored screen will be necessary for photographs.
Electronic instruments:

The following are the specifications for the electronic medical instruments:

1. **Stethoscope**: The stethoscope should be a small wireless microphone of high sensitivity and excellent frequency response. It should have a response range between 20-20000 Hz. Its sensitivity should be tunable so that extraneous noises other than breath sounds, bruits, and heart tones are focused on while extraneous noise such as conversation, room noise, other body noise is excluded. It would be useful to have this device to be thick in the hand and fingers, similar to how physicians would hold a stethoscope bell. The listening point should be conical, similar to the stethoscope bell. A diaphragm slide or cap could be available in a flip-up type configuration. The bells of the device could be interchangeable with small bells for pediatric or neonatal use. The audible sounds would then be transmitted to the computer and converted to a wave file. This could be played real time through the PC in an amplified manner for both the physician and patient to monitor or be packaged and sent via the net to a colleague or interpretation center as well. The physician could label these wave files according to position such as precordial area, right axilla, apex, etc. The wave files would be labeled then with the patient’s identifying data, date, and a counter, as well as the anatomic position from which the sounds were captured. Additionally, if there is a command or maneuver such as inhale, bear down, etc., this could be captured audibly and labeled onto the sounds as well.

2. **Otoscope**: The otoscope device should be lightweight and have the basic T configuration of the usual otoscope found in the office. A difference would be that there is no optical viewing point port for the physician (There may be a way to introduce this using optical viewing port or video viewing port but the technology would have to be explored. We may want to put in the pattern an either/or optical or video viewing port on the back of the instrument. The main image capture would occur via a video card or video camera in the rear of the otoscope. We will need a fairly high-resolution capture card that gives appropriate images. I am uncertain as to commercially what mega-pixel this might be. This image would then be labeled and sent to the PC tablet for cataloging. Once again, dialogue or narrative information could be provided by the physician such as Valsalva, right ear, etc. The images could be shared directly with the patient from the tablet PC. (There could be provisions in the room for alternative video monitors to provide the patient with an image.)

3. **Ophthalmoscope**: The ophthalmoscope device would have similar provisions as the otoscope. There, however, would be a camera. There would need to be a lens wheel with the usual corrective diopters found on a standard ophthalmoscope. We would also need both white and green illumination. The ophthalmoscope would have a similar high-resolution capture device. In addition, we should look at the potential of using fish eye or other lenses to obtain panoramic retinal views. Within a capture of the retinal image, we should be able to have an mpeg file to capture a number of images serially to paste together a panoramic map of the
retina if possible. Physician narrative could also be provided to give the necessary descriptive data such as eye maneuver, etc.

Note that other data could be employed such as IR mapping of the corneal surface, measurement of light backscatter from lens and cornea, and possibly puff test for glaucoma.

Note: I would like to collaborate Mike Stoner about his retinal camera system and what he does within his exam format. It may be able to create a mini-corrective vision laboratory as well. Other possibilities come with using the monitor to detect visual acuity within the exam.

4. **Thermometer**: This would possibly be integrated with the otoscope so that we could get an IR reading from the tympanic membrane region of what the patient’s temperature is.

5. **Blood pressure**: We could design a wireless blood pressure cuff to take the blood pressure. This would include a microphone that fits over the brachial artery area as well as manual or automatic inflation methods for the cuff itself. We would need large cuff availability for obese patients which may include a different type of microphone system to accommodate their larger anatomy.

6. **Dermatologic camera**: We would a HD dermatological camera to characterize rashes. The first would be a high-resolution capture system with macro lenses. Next, we could provide IR and UV imaging of these rashes as well as possible photo-fluorescent methods of characterization.

7. **Barcode reader**: A barcode reader could be integrated into the computer frame itself and enable rapid documentation of medications, devices, etc. Barcodes may be used to identify people as well.

8. **RFID reader**: RFID reader could also give rapid identification of medications, devices, and identify people as well.

9. **Fingerprint reader**: A fingerprint reader could be used to identify the provider and the patient. The cataloging of the fingerprints would be useful in forensics as well.

10. **Electronic speculum**: Electronic speculum could integrate with the plastic type speculum and provide a panoramic camera image of the internal female genital tract. In addition to plain light, a photo-florescent or filtered type light for detection of dysplastic change of the cervix and vagina could be employed. (Detection of vaginal intraepithelial neoplasia and cervical intraepithelial neoplasia.) The imaged data could be sent to the computer or to monitors to share with patient or telemedicine methods. Need to check data from cervicography and opalescent cervical imaging. This could create an optical no-touch Pap smear. Additionally, it could spray the cervix and genital tract with chemical developers for detecting dysplastic change, HPV, etc.

11. **Micro-labs**: Need to enter discussions about potential for compact medical laboratory testing modules that were originally developed by Beckman but the project was discarded. These electronic testing modules may provide a desktop
laboratory for blood work, urine, etc. We will talk to Susan about these micro-labs.

12. **Software requirements**: The tablet must fit within the usual interview format of patient questioning where the physician asks questions to ferret out the symptom set that the patient is experiencing. This symptom set then integrates into the physician’s schema of what the most likely diagnosis is. The schema itself is an expert decision-making system for the most part where things such as the patient’s age, social situation, race, activities, and habits are also integrated into the interpretation of the symptom set. In the first iteration, we would not want to interfere with the expert decision making process involved in diagnostics. We would simply observe it. Then, if the electronic medical record is integrated, we will be able to see what the success rate is of the diagnostic processes. This would provide a knowledge base from which to make supportive decision-making algorithms for more novice practitioners.

The primary purpose is to ease documentation burdens and to provide more complete information to the physician/provider.

The second major advantage would be to speed the formation of the treatment plan by providing templates such as automated prescription pads with direct fax capability to the pharmacy, drug check interaction check with the EML and ready referenced dosage and interaction check with the various meds and to provide the patient detailed information on the medication. This patient education piece could be done either in a standard paper handout in the language which the patient reads best or an mpeg CD or other electronic narrative/presentation download.

13. **Gathering of symptom set**: The nature of the visit could be characterized by the given objectives: Investigation of fever, minor illness, particular type of trauma, arthritic symptoms, etc. These would match well with ICD-9 descriptors. The patient could preload many of his/her symptoms by using a review of systems format and targeted questions for their particular complaints. These targeted questions would be developed from the literature and experience of experts as to what the quality points are with the given complaint. With a common cold, what sort of questions should be answered, what sort of questions should be also answered to ensure that there is not a dangerous or another diagnosis that underpins these complaints.

In addition, the patient could do a health update to make sure that their record is complete. We may need to look at a way in which the patient’s personal health record could smoothly integrate into an electronic medical record for more complete and humane medical treatment.

The symptom set is really analogous to the history of present illness section found in most medical documents. This symptom set could be arranged in a list of pertinent positives or negatives. Within each pertinent positive, the physician could score the severity of the symptoms, onset, duration, and associations. This scoring could also be done by an experienced RN or trained physician’s assistant.
It is important to realize that symptom data not only has a function of presence or absence but rather quality and certainty. For example, just because the patient says they have chills, does not mean they have rigors. We need to develop presentations and data sets that bridge the communication gap between the provider and the patient to ensure accurate information interchange.

The patient could be pre-interviewed and could preload a great deal of this information prior to the actual physician encounter. In addition, the information could be loaded through a facilitator and audited in a similar manner. It is important to use the power of electronic media to communicate. For different symptoms, one can envision graphics and animation to help the patient more fully explain themselves and their symptoms. Such methods would increase the quality and certainty of the symptom set data.

14. **Physician checkmark method**: If the physician is eliciting or auditing data, it could be done through a check-off basis where the symptom would appear and have a gradation of yes, no, maybe. Then a screen would appear with the customary data such as location, intensity, onset, precipitating factors, non-precipitating factors, relieving factors, prior treatment, etc. This symptom set and portion of the medical history provide the subjective block of the typical SOAP noted. Within the SOAP note, there would be a review of current medications and allergies. Additionally, within the patient-elicited section, major social events could be included and stressors. If the stressor is significant enough such as divorce, death of a loved one, pet, etc., an automated depression score method such as the Beck Index or other tool could be used automatically. Additionally, portions of the patient’s past medical history or chronic diagnosis list could be brought to attention. If the patient comes in with urinary tract infection, the physician could examine different bits of their medical and surgical history to see if it may be remotely related, i.e., there is evidence of diabetes or true diabetes, prior surgery.

15. **Gathering objective data on the screen**: The physician would have a ready method to photograph the patient, gather the vital signs. A palette of physical findings would appear according to organ system examined. The physician then would check off findings and impressions and insert any images or wave files as appropriate.

16. **Assessment**: Assessment is done by expert decision-making methods. However, we should lineup the data, i.e., symptoms and objective data so that the expert can readily view all this and discard or raise its importance based on their heuristic methods of data computation. The expert could check this palette off as important, not important, etc. Long-term tracking of these data sets would help researchers explore the medical expert decision making process.

17. **Treatment plan**: The treatment plan section would provide an automated method to expedite the treatment plan. As mentioned before, the ordering of medications and the associated pharmaceutical data with selecting medications and dosage would be done. Consultative referral would be done. Possibly within the consultative segment, the central questions that the referring physician wants answered or remedied could be checked out. The majority of the referral letters
could be almost boilerplate. Voice recognition or transcribed methods could further facilitate the interaction between referring physician and consultant.

18. **Lab test**: Lab tests could be readily ordered and the associated patient instructions for the test would be automated.

19. **Radiological studies**: Radiological studies could be ordered as well as the record used to cue the radiologist as to the intent and exact purpose of the study.

20. **Pathology orders**: The biopsy results could be tagged with the clinical data, photos from whence it came, and the native state of the tissue as well.

In conclusion, the PC electronic data management and the flexibility of wireless communications can be leveraged to make a more efficient, effective, and safer patient-physician interaction. These data sets and programs could also be adapted to nursing-patient interactions either in the outpatient, field, or hospital setting.

We need to ensure that HIPAA-appropriate sanitation aspects of this equipment occur. Sanitation and cleaning of the various medical instruments would be important. Generally, this can be done with an alcohol wipe. The screen and the physical device need to be splash resistant and to be able to be decontaminated if any body fluid spills occur on it. This may necessitate that a minimum of ports or secure ports that can be readily cleansed.

James Dean Bauer, MD, FACOG, FICS