Successful Secure HD Streaming Telecytology for Remote Cytologic Evaluation

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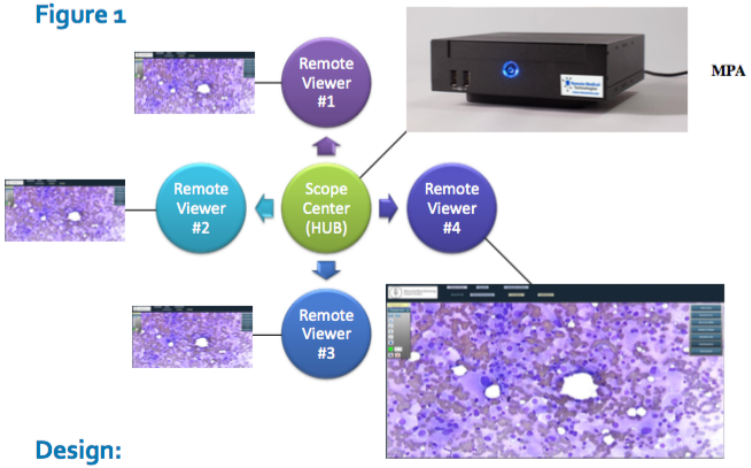
Background

In 2014 within our health system, there was expansion of numerous remote stationary locations requiring on-site fine-needle aspiration (FNA) smears and touch imprints of core biopsies (CBs). An operational evaluation of resources showed that cytotechnologists would be available for on-site preparations, however allocating the corresponding appropriate number of on-site attending pathologists was not possible. Thus preliminary adequacy evaluations by the cytotechnologists was possible, but without an attending pathologist verification in real-time. The activity therefore was non-billable, leading to a loss of a potential revenue stream.

Through a process re-evaluation utilizing HD streaming telepathology, we were able to create a process workflow that overcame this constraint of physical availability of an attending pathologist. This would generate a positive revenue stream whereby funds can be directed towards incentive payments and the upfront costs of the system implementation while also sustaining maintenance costs of the HD streaming telecytology (TC) solution.

Figure 1



Design:

Technical Description:

Remote Medical Technologies (RMT) was selected as the highly secure dynamic streaming TC solution. Figure 1 provides a high-level overview of the RMT architecture which is based on a spoke and wheel networked client-server concept. The focal point is the scope center which comprises of a linux server. Termed a "Multi-Protocol Appliance" (MPA), this server coordinates broadcast of live images captured through HD video cameras. Our HD video cameras are MICROCAST HD 3CCD 1080p which generates video at 60fps. The captured digital HD images are converted into signals which eventually are routed to the MPA through intermediary devices termed "iServe- M-Encoders". These intermediaries are directly connected to the HD cameras and communicate with the MPA securely over the intranet. Remote Viewing is done on 28" HD LED Samsung U28D590D monitors. The entire pipeline of the image stream is contained behind our extensive institutional firewall.

From the scope center, the MPA is able to "broadcast" the digital signals from multiple HD cameras in real-time. Depending on the local subnet architecture, only one MPA is necessary per subnet and is able to handle multiple iServe-M-Encoders directly connected to individual HD cameras. The MPA can drive concurrent streams to multiple participants at up to 60 fps depending upon customer bandwidth availability. Remote viewing is web-based and performs optimally on Google chrome. Our intranet network speed is 1 Gbps, though beautiful high speed image performance is achievable even at bandwidth speeds between 3 and 4 Mbps.

Table 1

TC cases (n=3006)			
Remote Locations			
Location 1 (IR)		1438	
Location 2 (IR)		958	
Location 3 (US)		166	
Location 4 (US)		284	
Location 5 (Endo)		146	
Location 6 (OR)		14	
Demographics			
# Patients		2675	
Mean age (range)		64 (3-98)	
Sex (male/female)		1.2/1	
Cytologic Evaluation	**Touch Prep**	**FNA**	
Location 1 (IR)	1090	348	
Location 2 (IR)	753	205	
Location 3 (US)	20	146	
Location 4 (US)	0	284	
Location 5 (Endo)	6	140	
Location 6 (OR)	0	14	
Total	**1869**	**1137**	**3006**

Process Workflow:

Because of the number of on-site locations, having an attending cytopathologist for on-site evaluation was not possible physically. This necessitated a process re-evaluation utilizing a streaming TC. An available cytotechnologist would come on-site for the slide preparation and selection of the region of interest (ROI). An attending cytopathologst at a central location, usually the main signout room or office, would then be contacted that the specimen is ready by the cytotechnologist operating the on-site microscope. The on-site microscope with HD camera connected to an iServe-M-Encoders and communicating with an MPA, then broadcasts the streamed images to the attending cytopathologist. Secure voice communication between cytotechnologist and cytopathologist for each session is performed through Vocera. Cellular content and adequacy were affirmed through TC where the cytology attending at a central location views live images seamlessly on HD monitors, through secure authentication mechanisms on the system backend.

Results and Discussion:

Since 7/2015 to 2/2016 , we performed a retrospective analysis of all remote TC evaluations for FNA and touch preps of CBs. Table 1 shows case breakdown per remote location, demographics, and cytologic evaluation. The mean age was 64 with a range of 3 to 98 years and there is a slight male predominance.

Table 2 shows an adequacy comparison between the TC adequacy assessment and the final adequacy. Our study shows that TC assisted preliminary adequacy assessment is highly concordant with the final cytopathologist rendered adequacy assessment. Perfect concordance was at 93.3% (2806/3006). An adequacy upgrade (inadequate specimen became adequate) was at 6.4% (192/3006) and an adequacy downgrade (adequate specimen became insufficient) was only at 0.2% (8/3006). The latter is the most relevant metric in this series.

Table 2

Comparison TC assisted adequacy with final adequacy			
TC assisted adequacy	Final adequacy		Total
	Adequate	Inadequate	
Adequate	2566	8	2574
Inadequate	192	240	432
Total	**2758**	**248**	**3006**

Our study, which is by far the largest study of an active implementation of TC, clearly shows the effectiveness of the implementation with this TC solution. Credit goes to the TC solution because of the user friendly interface and simplified process flow. Despite interruption to view a TC assessment for the attending cytopathologist, obviated is disruption which occurs with figuring setup with alternate desktop image sharing solutions such as Web-Ex or Go to Meeting. Another factor which may account for such high concordance is the outcome measure of determining adequacy for the TC evaluation. Determining adequacy is a simpler diagnostic task than preliminary cytologic diagnosis for instance. It is possible that if a different outcome measure was chosen like preliminary cytologic diagnosis, the concordance might have been lower.

Another strength of this TC solution is security with logins and authentication with prompted access of end users at remote viewing sites to see the protected image stream. The setup for this TC solution makes hacks into the image streams within our firewall exceptionally difficult. The logins and authentication additionally to our extensive institutional fire wall, create many barrier layers to external attacks. Upkeep and maintenance issues as well as authentication protocols are done over the internet outbound to the main RMT headquarters. The architecture is such though that anyone outside the our institutional firewall including at the RMT headquarters is not able to view the images streamed within the firewall between the iServe-M-Encoders, MPA, and remote viewers. Such an architecture was easily able to meet our strict security compliance requirements.

Conclusion:

The strengths of this TC solution are usability and seamless integration into TC adequancy workflow, along with robust security and authentication mechanisms. Image quality and speed are excellent with minimal demands on bandwidth. Our implementation shows high perfect concordance. Adequacy upgrades are minor but not unexpected since only part of material is available during initial review. Most relevant is a near zero adequacy downgrade. Our implementation has been so successful that implementation of this TC solution has been scaled up to encompass mobile carts and mobile devices with the results to be reported in a future study.