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Prospective Analysis of Radiology Resource Utilization and Outcomes for Participation in Oncology Multidisciplinary Conferences

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Rationale and Objectives: Radiology participation is necessary in oncology multidisciplinary conferences (MDCs), but the resources required to do so are often unaccounted for. In this prospective study we provide an analysis of resource utilization as a function of outcomes for all MDCs covered by an entire radiology section and provide a time-based cost estimate.

Materials and Methods: Following institutional review board approval, prospective data on all MDCs covered by abdominal radiologists at a single tertiary care academic center were obtained over nine weeks. A predefined questionnaire was used by a single observer who attended every imaging review and recorded the total time spent by the radiologists and several outcome measures. The total time recorded was used to provide a time-based cost estimate using a national salary survey.

Results: Six radiologists participated in a total of 57 MDCs, with 577 cases reviewed and discussed. 181 (31%) cases were performed at outside facilities requiring full reinterpretation. Clinically significant revisions to original reports were recorded in 107 (18.5%) cases. Radiologist input directly resulted in alteration of cancer staging in 65 (11%) patients and specific recommendations for follow-up diagnostic workup in 280 (48%) of cases. The mean total time devoted by the staff radiologist per week to MDCs was 18.7 hours/week, nearly a half of full-time effort, or 8% of total effort per radiologist. The total annual projected cost of radiology coverage for each weekly MDC was \$26,920.

Conclusion: Section-wide radiologist participation in MDCs directly resulted in change in clinical management in nearly half of reviewed cases. This was achieved at a notable time cost, highlighting the need for efficient integration of radiology MDC participation into radiologist workflow and compensation models.

Key Words: Multidisciplinary conference; Radiology workflow; Outcomes.

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The primary author declares no conflict of interest.

Although the senior author Dr. Leo L Tsai, MD, PhD, MSc; is a consultant for Agile Devices, Inc., Boston, MA with an equity stake- this relationship has no direct impact on our data or paper.

SUMMARY SENTENCE: Radiologist participation is critical in multidisciplinary conferences; however, this is accompanied by a high time-based cost, which warrants optimization with the radiologist workflow and compensation structure. **Address correspondence to:** A.S.B. e-mail: abhangle@bidmc.harvard.edu

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INTRODUCTION

Multidisciplinary conferences (MDCs) are an increasing part of radiologists' workflow not only at major academic and tertiary referral centers but also in the community setting (1). The American College of Surgeons first established the Commission on Cancer accreditation program to provide standards for the establishment of MDCs (2). Now there are over 1500 certified medical centers in the US, with each site required to register the composition of their MDCs with minimum attendance rates for participants, including radiologists.

The importance of a multidisciplinary approach to management of oncology patients and the importance of a radiologist's presence and contribution to improved clinical decision making has been studied and validated in the context of breast cancer, hepatocellular carcinoma, pancreas cancer, gastrointestinal tumors, and gynecologic cancers (3–9) among others. A majority of these papers focus on a multidisciplinary

approach to patient management in an oncology setting or the added value of reinterpretation of imaging studies by specialized radiologists. For example, Pawlik et al. reviewed 203 cases in one multidisciplinary pancreas clinic and demonstrated 38 (19%) cases with altered clinical stage and overall 48 (24%) cases with altered management as a result of the discussion at the MDC that also included input from radiologists (10).

MDC impact on radiology and pathology workflow was previously studied in a single conference setting, highlighting time demands, but without a translation into cost, or reference to outcomes (11). Since that study, the radiologist's role in MDCs has been shaped by technical improvements such as the introduction of online transfers of outside hospital (OSH) studies directly to picture archiving and communication systems (PACS), as well as the overall increasing number of MDCs, necessitating a more current evaluation. Furthermore, there has not been a study that has examined the impact of MDC coverage across an entire section.

The purpose of this study is to fill these knowledge gaps by collating both resource and basic outcome data from a consecutive set of MDCs currently supported by an entire imaging section, and by calculating the associated cost.

MATERIALS AND METHODS

This prospective study was approved by our institutional review board and was Health Insurance and Portability Accountability Act compliant. The study was conducted at our 673-bed hospital which also serves as a tertiary referral oncology center with specialized oncology care, serving approximately 725,000 outpatients a year. Our hospital network includes a network of 18 satellite hospitals and partnered health centers that refer oncology patients for specialized care.

Description of Conferences and MDC Workflow

This study encompasses all (a total of 7) weekly MDCs covered by the abdominal section at our tertiary referral center: Gastrointestinal Oncology; Genitourinary Oncology; Gynecologic Oncology; Liver Tumor Board, Liver Tumor Multidisciplinary Clinic, Pancreaticobiliary Tumor Board, and Pancreaticobiliary Multidisciplinary Clinic. The description of conference style and participants is provided in Table 1. Although all of these conferences are focused on oncology patients, non-oncology cases referred for second opinion to our clinical colleagues from the hepatobiliary or pancreas center are also included. The MDCs are staffed by six fellowship-trained abdominal radiologists (out of a total of 15 members of the section) who subspecialize in the conference focus areas, with one faculty member covering two of the conferences. There are backup radiologists from the same group who attend the MDC if the primary radiologist is unavailable. An abdominal imaging or body MRI clinical fellow typically participates in each of the conferences.

The radiologists' workflow for MDCs is comprised of two parts: a review of the cases prior to the conference

TABLE 1. List of MDCs and Participating Interdisciplinary Team Members in Addition to the Attending Radiologist and Fellow

Conference	Participating Staff (in addition to the presenting attending radiologist and fellow)
PTB	Interventional Radiology, Gastroenterology, Interventional Gastroenterology, Surgery, Pathology, Oncology, Radiation Oncology, Nurse practitioners.
PMDC	Interventional Radiology, Surgery, Pathology, Oncology, Medical Oncology, Radiation Oncology, Physician assistants, Nurse practitioners.
Gyn Onc	Interventional Radiology, Surgical Oncology, Pathology, Oncology, Radiation Oncology, Medical Oncology, Nurse practitioners.
GI Onc	Gastroenterology, Interventional Gastroenterology, Pathology, Surgery, Oncology, Medical Oncology, Radiation Oncology, Nurse practitioners.
GU Onc	Interventional Radiology, Surgical Oncology, Pathology, Oncology, Radiation Oncology, Medical Oncology, Nurse practitioners
LTB	Hepatology/Transplant Hepatology, Interventional Radiology, Surgery, Pathology, Oncology, Radiation Oncology, Physician assistants, Nurse practitioners.
LTMDC	Hepatology/Transplant Hepatology, Interventional radiology, Surgery, Oncology, Medical Oncology, Radiation Oncology, Physician assistants, Nurse practitioners.

Abbreviations: PTB, Pancreaticobiliary Tumor Board; PMDC, Pancreaticobiliary Multidisciplinary Clinic; Gyn Onc, Gynecologic Oncology; GI Onc, Gastrointestinal Oncology;

GU Onc, Genitourinary Oncology; LTB, Liver Tumor Board; LTMDC, Liver Tumor Multidisciplinary Clinic.

and presentation of cases at the conference. The initial report of these cases is provided either by any of the radiologists from the same group, but not necessarily those reviewing cases for the MDC, or by radiologists at outside institutions. Centers outside our institution that are affiliated with our network have separate radiology departments and their studies need to be imported into our PACS, and are thus considered outside studies. Reviews are usually performed within 24 hours prior to each conference after a final list of cases is sent by the MDC coordinators to all participants. A clinical fellow usually previews the cases, followed by a review with the staff (attending) radiologist, who makes all final decisions regarding image interpretation and recommendations. The findings are then presented at the MDC; at five of the MDCs, the fellow is the presenter, while the attending presents at the two pancreaticobiliary MDCs.

TABLE 2. Radiology Outcome Measures

Evaluated criteria (recorded for every case)	Explanation or Examples
Any changes from the original report that were presented at MDC	Examples: Undiagnosed metastases, changes in local tumor staging, previously undetected pulmonary embolus, or re-characterization of “nonspecific liver mass” to a hemangioma on review. Changes that did not require communication, for example an incidental small duodenal diverticulum, were not counted.
Change in cancer staging for oncology cases	Examples: Identification of new metastases or lymphadenopathy; changes in local staging
The radiologist was directly consulted at the MDC to guide further diagnostic workup or follow up.	Example 1: Sub-centimeter hypodense liver lesion is seen during CT evaluation of a potentially-resectable pancreatic head mass, and MRI is recommended to exclude metastasis. Example 2: A liver lesion seen on recent CT was revealed to be a hemangioma on a prior multiphase CT from an OSH. A follow-up MRI was therefore canceled.

However, the corresponding attending is present at every conference for any additional questions or review of add-on cases.

Data Collection, Analysis and Interpretation

Data was collected from MDCs conducted consecutively from June 20, 2018 to August 24, 2018. A single researcher (N.P.) attended all review sessions with the clinical fellow and attending radiologist. The researcher then attended all of the MDCs, with the exception of Genitourinary Oncology, which overlapped with the Liver Tumor conference. For the Genitourinary Oncology conference, the attending radiologist covering the MDC (L.T.) recorded the data from that conference and emailed the results to the researcher at the conclusion of the conference. The attending radiologists were all fellowship-trained in abdominal imaging with 3 to 23 years of faculty experience. All studies were reviewed on a PACS workstation. Any studies from an OSH were required to be imported into our PACS system before being reviewed for an MDC.

The data collected by the observer was obtained using the same standardized questionnaire for every MDC. The data included logistical information, including the time spent by the fellow and the attending previewing and reviewing the cases, respectively, the number of OSH versus in-network cases that were reviewed, the time spent reviewing OSH studies, and the number of “add-on” cases (less than 12 hours before the MDC or cases added on at the MDC without prior notice) that were requested after the final MDC lists were sent. All radiology findings and recommendations discussed at review and MDC were recorded for each case, along with management decisions reached by the multidisciplinary group.

The data from each case was then measured for four basic outcomes that highlighted contributions directly attributable to the radiologist: 1) Any changes from the original imaging report that the attending radiologist deemed clinically

impactful to warrant presentation at MDC, 2) changes in cancer staging for oncology cases, and 3) instances when the radiologist either recommended a new diagnostic imaging study at the MDC, or 4) recommended cancelling a planned follow-up imaging study for lack of added value. Examples for each are provided in [Table 2](#).

All data were transferred immediately to an anonymized master spreadsheet for tracking and statistical analysis. Categorical variables were described by counts and percentages while continuous variables were described by mean and standard deviations.

Conversion of radiology time to full time equivalents (FTEs) was based on a standard 40-hour work week. A cost conversion was calculated using the US national median salary obtained from Medscape’s 2018 compensation overview (12).

RESULTS

Data were collected over a total of 57 MDCs over nine weeks. Means are presented as mean \pm standard deviation. There was a mean of 8.1 ± 0.7 and median of eight MDCs for each conference type. A total of 577 cases were reviewed, with a mean of 10.1 ± 3.9 and median of nine cases reviewed per conference. Key results are presented below, with summary data shown in [Table 3](#).

Review time

Clinical fellows spent a mean of 2.2 ± 1.5 hours and median of 2.5 hours per MDC, or 13.7 hours/week. Attending radiologists spent a mean of 2.0 ± 0.5 hours and median of 2.0 hours per MDC, or 12.4 hours/week. These times did not include the time spent by the attending radiologist and the fellow presenting at the conferences, which were each an hour long. When taking this into account, clinical fellows and attending radiologists spent a total of 20.0 hours/week and 18.7 hours/week, respectively, exclusively on MDCs.

TABLE 3. Summary of Conference and Case Numbers, Review Times, and Outcomes

	GI Onc	Gyn Onc	GU Onc	LTMDC	LTB	PMDC	PTB	Totals	% of total	Average per week
Number of Conferences and Cases										
Total conferences	8	8	9	9	7	8	8	57		6.3
Total No of Cases	124	61	73	96	58	59	106	577		64.1
Add-on Cases	21	3	16	4	1	8	12	65	11.2 %	7.2
OSH Cases	28	21	24	27	14	21	46	181	31.4 %	20.1
Review Time (hours/week)										
Total Review Time in hours (Attending)	15.7	13.1	17.5	20.5	12.5	15	17.7	112		12.4
Total Review Time in hours (Fellow)	22.3	19.3	27.5	27	17.8	2.5	6.7	123.0		13.7
Time reviewing OSH cases in hours (Attending)	4.5	3.6	6	4.2	3.5	2.2	5.1	28.9	28.5 %	3.2
Time reviewing OSH cases in hours (Fellow)	3.5	3.0	6	4.2	3.4	0.3	2.5	22.7	18.5 %	2.5
Total Attending time (Review +MDC)	23.7	21.1	26.5	29.5	19.5	23	25.7	169		18.7
Outcomes										
Revisions to report presented at MDC	22	10	11	19	6	17	22	107	18.5 %	11.9
Cancer staging altered	11	8	9	11	3	10	13	65	11.3 %	7.2
Follow up imaging recommended by radiologist	52	19	33	56	33	25	62	280	48.5 %	31.1

Abbreviations: GI Onc, Gastrointestinal Oncology; Gyn Onc, Gynecologic Oncology; GU Onc, Genitourinary Oncology; LTMDC, Liver Tumor Multidisciplinary Clinic; LTb, Liver Tumor Board; PMDC, Pancreaticobiliary Multidisciplinary Clinic; PTB, Pancreaticobiliary Tumor Board.

OSH cases and Add-Ons

181 cases (31 %) were OSH studies. The clinical fellow spent a mean of 0.40 ± 0.37 hours and median of 0.45 hours reviewing OSH studies, or 2.5 hours/week (12.5 % of total), while the attending spent a mean of 0.51 ± 0.32 hours and median of 0.5 hours, or 3.2 hours/week (28.5 % of total). 65 cases (11.2%) were add-ons. These included cases that were emailed to the radiologist after the official final list was emailed to the MDC group, as well as cases added during the MDC. These cases were typically reviewed during or immediately after the conference directly with the MDC team, and the time spent could not be reliably quantified to include in the total measured review times.

Outcomes

Revisions to the original radiology report were presented at MDC in a total of 107 (18.5%) cases. Of these revised reports, more than half (65 cases, or 60.7 %) involved alterations (both upstaging and downstaging) in cancer staging (11 % of total cases). In 280 (48.5 %) of cases, the radiologist provided direct guidance for diagnostic follow-up at the MDC.

Cost

The US national median radiology salary in 2018 was \$401,000 (12). In our study, a total of 18.7 hours/week were spent by six staff members, or 3.1 hours/week per attending. This corresponds to a yearly cost of \$32,080 per physician or

\$188,470 for the section, and an annual cost of \$26,920 for each weekly MDC.

DISCUSSION

MDCs are a critical component of the clinical and educational missions of medical centers. The benefit of radiology input in MDCs is widely accepted, however, the costs associated with this have not been previously studied. Our study is the first to provide an estimate of such resources while also sampling across a diverse mixture of MDC types covered by an entire radiology section. We also focused on the time spent by clinical fellows and attending radiologists previewing studies and participating at each MDC and translated it into FTE for attending radiologists to assign an estimated cost per physician, per section, and per MDC. These observations have implications on clinical workflow and compensation models as there continues to be an increasing overall demand for radiology support in MDCs as well as emphasis on value-based healthcare as highlighted by the American College of Radiology (ACR) Imaging 3.0 initiative (13).

The time spent by faculty radiologists on MDC conferences averaged 18.7 hours/week, or 0.47 FTE. When divided across the six participating faculty members, this represents 3.1 hours/week/radiologist, or 8 % of total effort per FTE. This is slightly increased in comparison to a study a decade ago that calculated 2 hours preparation time per meeting hour spent by the radiologist for one specific MDC involving both imagers and pathologists (11). Our calculated time of 3.1 hours/week/radiologist represents a lower limit and likely an underestimation, as other MDC-related consultations routinely occurring outside of the

review period, in particular the time spent on add-on cases (11.2% of total cases) could not be accurately recorded. Although more add-on cases may have a benefit in that the radiologist takes less time to review such studies, this has been discouraged by our practice as such cases are not reviewed to the same depth as others, nor are they viewed properly on a PACS station, increasing the risk of errors or misses. Additionally, our department benefits from having clinical fellows help reduce the faculty preparation time. Our abdominal fellows participate in MDCs as part of a dedicated conference rotation, and we consider this activity an essential part of our academic mission (14).

We calculated a yearly cost of \$32,080 for each radiologist to participate in the MDCs in our study. This translates to \$188,470 per year total for coverage of all 7 MDCs, or an annual cost of \$26,920 for each weekly MDC. If we extrapolated this nationwide using conservative estimate, accounting only for 1500 Commission on Cancer accredited sites and assuming only a single weekly multidisciplinary conference at each site and a minimum of 80% participation rate as required by Commission on Cancer (2), the cost of radiology effort would be approximately \$38.4 million per year in the US.

Nearly one-third of reviewed cases (31.4%) and the total time spent on review by attendings (28.5%) were OSH studies, reflecting a large community referral pattern driven mostly by cancer care. While OSH cases presented at the two liver MDCs always resulted in an official second opinion report issued by our radiologists, this was not performed for the remaining 5 MDCs, where the findings were instead summarized on an online medical note generated by the conference coordinators. This meant that only 41 out of 181, or 22.6% of imported OSH scans were issued full radiology reports following MDC review. Multiple studies have stressed the value of official second opinion reads by subspecialists (7,15–21), highlighting a potential area of practice improvement. The increased number of second opinion reports may also generate additional revenue in the form of professional fees, though at our institution a portion of our OSH volume comes from our network affiliates which, in our state, precludes additional billing. Thus, the move towards requiring an official second opinion read on all OSH studies would likely add to total time costs with a partial increase in revenue.

In 48.5% of cases the radiologist provided direct recommendations for follow-up or next imaging studies. Much of this likely stemmed from additional clinical information discussed live at the MDCs and participation by subspecialized radiologists. These results are concordant with the results from the study by Chingkoe et al. (7) where a change in management was seen in 38.5% of patients following review by the radiologist for a single pancreas MDC. This change in management encompassed changes in diagnosis; in clinical stage; in treatment as well as any additional workup that might be required.

Changes to the original report were presented by radiologists in about a fifth of all cases. Of these, more than half (11% total) were changes to oncologic staging, similar to that

observed at a pancreas-specific MDC (8.7%) (7). This was in part due to subspecialty staff reviewing or reinterpreting in-house and OSH studies, thereby providing second opinion expert reads. We also attribute some of these discrepancies to additional clinical history or supplementary studies obtained during MDC review that lead to new observations or interpretations. Discrepancies resulting from interpretive errors or misses are placed in our quality review database for review and education.

In many radiology departments there is no time reserved specifically for MDC review. This is currently the case at our institution, where there is no dedicated time allotted to the staff for reviewing cases for MDCs and the effort required is diverted from clinical or personal time. This can present a challenge in sections where the existing clinical workload may be at capacity and MDC participation may not be captured in traditional RVU-based compensation models. Given the trend towards increased utilization of subspecialized MDCs for patient management, there may be a need to reconsider workflow designs, particularly at a time when burnout is highly prevalent (22,23). Indeed, since this study, new lymphatic, pelvic floor dysfunction, and prostate MDCs have been added, with coverage provided by the same group of six radiologists. With the incorporation of these new MDCs, we estimate the total effort per covering radiologist to be increased from 8% to 10%.

There may be several solutions to address the increased radiology demand for MDC participation. The creation of protected time to allow for uninterrupted MDC reviews would provide some separation from concurrent clinical demands and would likely improve the educational component for the fellow. A centralized and streamlined approach to importing OSH studies and assigning them earlier to the reviewing radiologist for official second opinion reads would save time and provide more consistent documentation. With the recent rise of telemedicine in response to the COVID-19 pandemic, virtual readouts and conference presentations offer greater convenience as MDCs can be performed remotely, potentially expanding the number of participating radiologists and reducing preparation time related to travel (24). Regardless of these changes, there will be an associated cost based on radiologist time, as shown in this study, which would need to be taken into account, whether it be borne by the department, the institution, or the radiologists themselves.

There are limitations to this study. First, we were limited to observing radiologists during scheduled reviews and at MDCs; additional input or decisions made outside of these times, for example, on follow-up emails or dictation of second opinion reports, were not recorded, resulting in an underestimation of the review/consultation time and some outcome measures. Also, not every OSH original report was available, leading to an underestimation of discrepancy rates.

We did not stratify the severity of discrepancies found in original radiology reports which would have allowed deeper insight into the overall impact of radiology input. However, we did establish a baseline threshold, based on the clinical

decisions of the attending radiologists, to only include findings that were significant enough to warrant discussion at the MDC; thus, discrepancies or new findings that were deemed irrelevant to patient care and management were excluded.

This study focused on a cost analysis specific to radiology. The outcomes observed in our study, for example the 11% changes in oncologic staging, suggest a clear benefit from radiologist participation in MDCs, as validated by prior studies. A more comprehensive cost-benefit analysis would be desirable though challenging due to the wide range of different MDC subspecialties, each requiring disease-specific measures. Such studies focusing on the general benefit of MDCs, including long-term clinical impact, patient satisfaction, and quality of life, are still needed (25). The rise of online medical records and accessibility of records via patient portals also poses unique challenges, for example in cases of discrepancies reported in second opinion reports (26,27). Indeed, the results of this study will form the basis of future investigation focusing on value analysis.

TAKE HOME POINTS

1. A total of 0.5 FTE, or 8% effort per radiologist, was required for MDC participation, corresponding to a yearly total cost of \$32,080 per radiologist. This translates to an annual total radiology cost of \$26,920 for each weekly MDC.
2. Changes to the original reports were made in approximately one-fifth of cases. This highlights the value of radiology participation in MDC and an established peer learning process.
3. A third of cases and attending review time were dedicated to review of outside studies. Professional fees from second opinion reports would help offset these costs.
4. The trend towards increased radiology participation in MDCs warrants consideration of required time and costs when incorporating this into institutional workflows.

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