EM Advances

Radiological errors in the *Canadian Journal of Emergency Medicine*

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ABSTRACT

Objectives: To systematically evaluate the accuracy of text descriptions and labeling of radiologic images published in the *Canadian Journal of Emergency Medicine* (*CJEM*). Error detection by radiologists and emergency physicians and the clinical significance and educational value of these errors were assessed. Errors were also correlated with radiologist involvement in publication and imaging modality.

Methods: Thirty-three issues of *CJEM* were examined from January 2003 to May 2008. Electronic copies of all radiologic images published were obtained with their caption and description from the text. Identifying information was removed to present images in an anonymous fashion. Images were presented to two radiologists who, working in consensus, critically appraised each image and accompanying text. Images were then presented to two emergency department physicians who, working in consensus, critically appraised each image and accompanying text. All images with errors detected by either radiology or emergency physicians were then discussed to determine if errors would have affected clinical management or educational value. The emergency physicians also identified ''underlabeled'' images where it was felt that further labeling would enhance their educational value.

Results: Forty-five articles with 82 images were obtained. At least one error was observed in 18 (40%) articles and 20 (24%) images. Two errors were present in three images, resulting in 23 errors. Of the 23 errors, 17 were image description errors and 6 were labeling errors. Five errors were detected by both radiology and emergency physicians, whereas 15 were detected only by radiologists and 3 were detected only by emergency physicians. Of these errors, 12 (52%) were rated as potentially affecting both clinical management and educational value, 5 (22%) as only affecting educational value, and 6 (26%) as nonsignificant. Radiologists were involved in six articles, including 12 images that contained no errors. There was no official radiologist involvement in 39 articles, including 70 images, 18 (26%) of which contained errors. In addition, 26 images were identified by emergency physicians as potentially benefiting from enhanced labeling to improve educational value.

Conclusions: Radiologic images published in the *CJEM* are generally of high quality; however, 23 errors were found in 82 images, 18 (78%) of which were rated as potentially affecting clinical management, educational value, or both. Radiologist involvement in the publication process may be of assistance as no errors were seen in articles that included radiologists as authors.

RÉSUMÉ

Objectifs: L'examen visait à évaluer méthodiquement la précision de la description des textes et des étiquettes se rapportant aux images radiologiques publiées dans le *Journal canadien de la médecine d'urgence* (*JCMU*). La détection des erreurs par des radiologistes et des urgentologues ainsi que la portée clinique et la valeur didactique de ces erreurs ont fait l'objet d'évaluation. Il y a également eu un établissement de corrélation entre les erreurs et la participation de radiologistes au processus de publication et de présentation des images.

Méthodes: Ont été examinés 33 numéros du *JCMU*, de janvier 2003 à mai 2008. Les copies électroniques de toutes les images radiologiques publiées ont été obtenues, de même que les légendes et les descriptions de texte s'y rapportant. Les renseignements personnels ont été supprimés afin de rendre anonyme la présentation des images. Celles-ci ont été soumises à deux radiologistes qui ont procédé de concert à une appréciation critique de chacune des images et de chacun des textes d'accompagnement. Les images ont ensuite été soumises à deux urgentologues qui ont procédé de concert à une appréciation critique de chacune des images et de chacun des textes d'accompagnement. Toutes les images sur lesquelles des erreurs avaient été signalées par les radiologistes ou par les urgentologues

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ont fait l'objet de discussion afin de déterminer si ces erreurs auraient pu avoir une incidence sur la prise en charge clinique ou sur la valeur didactique. Les urgentologues ont aussi relevé les images dont l'étiquetage leur semblait insuffisant et qui auraient pu gagner en valeur didactique si les légendes avaient été davantage explicitées.

Résultats: Ont été extraits 45 articles accompagnés de 82 images. Une erreur au moins a été signalée dans 18 (40%) articles et sur 20 (24%) images, et 2 erreurs ont été relevées sur 3 images, ce qui a porté à 23 le nombre d'erreurs. Celles-ci étaient réparties comme suit: 17 concernaient la description des images et 6, l'étiquetage. Cinq erreurs ont été détectées par les radiologistes et par les urgentologues; 15, par les radiologistes seulement; et 3, par les urgentologues seulement. Sur toutes ces erreurs, 12 (52%) étaient considérées comme susceptibles d'avoir eu une incidence sur la prise en charge clinique et sur la valeur didactique; 5 (22%), comme susceptibles d'avoir eu une incidence sur la valeur didactique; et 6 (26%), comme négligeables. Des radiologistes ont participé à la publication de 6 articles, dont 12 images exemptes d'erreur; par contre, aucun radiologiste n'a participé officiellement à la publication de 39 articles, dont 70 images,et 18 (26%) d'entre elles contenaient des erreurs. Enfin, les urgentologues ont relevé 26 images qui auraient pu gagner en valeur didactique si les étiquettes avaient été davantage explicitées.

Conclusions: Les images radiologiques publiées dans le *JCMU* sont généralement de bonne qualité; toutefois, 23 erreurs ont été détectées sur 82 images, dont 18 (78%) étaient considérées comme susceptibles d'avoir eu une incidence sur la prise en charge clinique ou sur la valeur didactique, ou sur les deux plans. Peut-être y aurait-il avantage à inclure les radiologistes dans le processus de publication puisque aucune erreur n'a été signalée dans les articles qui comptaient des radiologistes parmi les auteurs.

Keywords: education medical, journalism medical, medical imaging, quality improvement, systematic review

Medical imaging has become an integral part of patient care. The ability to visualize a disease process by peering inside a patient's body makes the field a valuable aid to clinical diagnosis.[1] For readers of a medical journal to advance their knowledge and change their current practice, publication accuracy is of the utmost importance. Published studies must contain enough information to make reproducibility a reality. Images must contain specific radiologic details to ensure that similar examination techniques and interpretations are possible when approaching a patient with a similar clinical concern. As a primarily visual field, radiology is to a large extent learned via images. Images must correlate unequivocally well to text descriptions, as well as accurately display the findings discussed. Herein lies the relevance of this study to examine the overall accuracy of recently published radiologic images in a clinical journal such as the *Canadian Journal of Emergency Medicine* (*CJEM*).

METHODS

Thirty-three issues of the *CJEM* from January 2003 to May 2008 were reviewed. All radiologic images published were assessed, including sonograms, computed tomographic (CT) scans, magnetic resonance images (MRIs), plain films, and conventional angiograms. All publication types were reviewed and included case reports, original research, letters, and "Knowledge Applied to Practice," which includes the "Diagnostic Challenge" and "Tips from the Trenches" sections of the *CJEM*. For an article from the Diagnostic Challenge to be included, both the image and the caption needed to be published in the "Answer" section.

Images were copied from pdf files into Microsoft *PowerPoint* along with their captions. Figures containing multiple image parts were presented together and considered a single image. Description from the text of the original article was presented on the same slide and identified with a "from text" label. This "from text" description was isolated by reading the paragraph in which the image was referenced, and any information pertaining to the image was copied directly into the *PowerPoint* slide. Any information that could potentially identify the original authors was removed. All images were labeled and cross-referenced to a database containing pertinent details about the original article. All text and labels were uniform between images.

The images were then reviewed by two board-certified general radiologists with subspecialty training in angiointerventional (G.W.S.) and musculoskeletal imaging (D.A.L.) with 14 and 4 years of postresidency experience, respectively, in conference. Images were evaluated in terms of labeling and image description. Labeling was assessed regarding whether the labels on the image adequately indicated the structure(s) intended. Image description was assessed regarding correlation between the described findings in the text descriptions and the pertinent positives and negatives visible on the image. These two factors were assessed using a binary system (adequate versus not adequate).

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For any image receiving a "not adequate" ranking, a short comment was written for explanation.

At a later date, all images containing errors were reassessed by the same two radiologists in conference and categorized as either major or minor errors. Errors displaying gross inaccuracy, either through inappropriate labeling or a lack of correlation between the image present and its description, were considered major and included in this report. Errors determined to be of little or no significance by the radiologists were classified as minor and discarded. Discrepancies at any time were resolved by consensus.

All images were then reviewed by two emergency physicians with 6 (K.L.M.) and 23 (J.E.S.) years postresidency experience in conference. Images were assessed based on labeling and image description. Additionally, images were assessed to determine if further labeling would enhance the educational value of these images. These images were classified as "underlabeled."

Following initial image review by the emergency physicians, all images were further reviewed by emergency physicians and one of the study radiologists (D.A.L.) in conference. All errors detected were assessed by the emergency physicians to determine if they would have potentially altered clinical management or educational value or were trivial from an emergency medicine point of view.

RESULTS

A total of 424 articles were published in the *CJEM* between January 2003 and May 2008; 45 (11%) included at least one radiologic image (Table 1). Articles containing images were almost exclusively found in case reports (n = 26) and the "Knowledge Applied to Practice" (n = 14) section of the *CJEM*, which includes the "Diagnostic Challenge" question-and-answer articles. Other article types included "Original Research" (n = 2), "Letters" (n = 2), and "Images" (n = 1). The 45 articles contained a total of 82 images. Eighteen (40%) articles and 20 (24%) images contained at least one error (see Table 1). Two errors were found in three images. Types of errors included 6 labeling and 17 image description errors. Emergency physician reviewers identified 26 images as being "underlabeled."

Imaging modality

Images included 32 plain films, 28 CT images, 10 sonograms, 7 MRIs including magnetic resonance angiograms (MRA), and 5 conventional angiograms (Table 2). Errors were observed in every modality, ranging from 19% (6 of 32) of radiographs to 32% (9 of 28) of CT scans (see Table 2). All errors, including whom they were detected by, the description, and whether or not the error was felt to potentially affect clinical management or educational value or was trivial, are summarized in Table 3. Five errors were detected by both radiologists and emergency physicians, 15 errors were detected by radiologists alone, and 3 errors were detected by emergency physicians alone (see Table 3). Of the 23 errors, 17 were errors of description, whereas 6 were labeling errors (see Table 3). Of these errors, 12 (52%) were assessed as potentially affecting clinical management and educational value, 5 (22%) as potentially affecting educational value only, and 6 (26%) as being trivial from the viewpoint of clinical emergency medicine practice.

Labeling errors

Six labeling errors occurred in six different articles (see Table 3). In two images, the arrows were not pointing to their intended structure as the arrows

Table 1. Types of articles published in the *CJEM* with at least one radiologic image and the number of errors present in each

Type of article	Total number of articles	Articles with images	Articles with errors (%)	Total number of images	Images with errors (%)
Original research	128	2	0 (0)	2	0 (0)
Case report	59	26	12 (46)	52	12 (23)
Knowledge applied to practice	56	14	4 (29)	23	5 (22)
Letters	44	2	2 (100)	4	3 (75)
Images	1	1	0 (0)	1	0 (0)
Total	288	45	18 (40)	82	20 (24)

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Table 2. Number of images and errors by imaging modality and radiologist involvement

	# of images	# of images with errors (%)	Total # of errors	Types of errors		"Underlabeled" images
				L	D	
Modality						
Plain film	32	6 (19)	6	0	6	12 (38)
CT	28	9 (32)	11	3	8	11 (39)
US	10	3 (30)	3	2	1	3 (30)
MRI (including MRA)	7	2 (29)	2	1	1	0 (0)
Angiography	5	1 (20)	1	0	1	0 (0)
Radiology involvement						
Involved	12	0 (0)	0	0	0	3 (25)
Not involved	70	21 (30)	23	6	17	23 (33)

CT = computed tomography; D = error of description; L = labeling error; MRA = magnetic resonance angiography; MRI = magnetic resonance imaging; US = ultrasonography.
A summary of the 26 images identified as potentially benefiting from increased labeling is listed in the "Underlabeled" column.

appear to have been translated with respect to their intended location (see Table 3, errors 1 and 2). One of these images was a contrast-enhanced CT scan of the neck illustrating an abscess (Figure 1).[2] Translation of arrows for the CT scan is described in Figure 1. It can be seen that the arrows would have had correct placement if not for this translation. The remaining four errors of labeling were either because of inconsistency between the image annotations and text (see Table 3, error 4) or arrows pointing to incorrect structures (see Table 3, errors 3–5 and 7). An example is the CT labeling error where the arrow that was supposed to be pointing to the right kidney actually points to the right perinephric fat (see Table 3, error 7) (Figure 2).[3] The right kidney is not visible on the image. Of these six labeling errors, four were deemed to affect potential clinical management and educational value, whereas two impacted educational value alone from the viewpoint of clinical emergency medicine.

Description errors

There were 17 errors of image description (see Table 3). Two of these errors were found in a single image (see Table 3, errors 11 and 12), and one error was also in an image with a labeling error (see Table 3, errors 7 and 8). Of these 17 errors of description, 8 were deemed to affect potential clinical management and educational value, whereas 3 impacted educational value alone and 6 were rated as clinically trivial from the viewpoint of clinical emergency medicine.

"Underlabeled"

While reviewing the images, the emergency physicians identified 26 images where the educational value could have been enhanced through more liberal use of labels to quickly illustrate the important clinical educational points (Table 4). One of these images was also identified as containing an error of incorrect labeling (see Table 4, error 1), and six contained errors of description (see Table 4, errors 2 to 7), with one image having two separate errors of description (see Table 4, error 3).

Radiologist involvement

Radiologists were authors or coauthors of six articles, which included 12 images. When a radiologist was one of the authors of the publication, no errors were identified. In contrast, when a radiologist was not one of the authors, errors occurred in 23% of images (see Table 2, Table 3, and Table 4). Radiologists were authors with 3 of the 26 underlabeled images where it was felt that more liberal labeling would enhance educational value. It should be noted that all three of these images were from the same article.

DISCUSSION

A physician working in isolation is no longer a satisfactory means of providing effective patient care. Instead, a vast network of interprofessional and interdisciplinary teams has emerged in an attempt to optimize diagnostic and treatment outcomes. In a

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Table 3. Description of identified errors as rated by emergency physicians and official radiologist involvement in the published manuscripts

Error #	Modality	Error type	Description	Detected by	Significance	Radiology (Y/N)
1	US	L	Arrow shift: while attempting to demonstrate a fluid collection in the Morrison pouch, the arrowheads intending to identify the liver point to the free fluid, the arrows intending to identify the free fluid point to the kidney, and one arrow intending to identify the kidney actually points to intraperitoneal fat or gaseous shadowing	R & E	CM & EV	N
2	CT	L	Arrow shift: CT of neck with abscess and internal jugular vein thrombosis. The arrow intending to label the abscess is on the right spinal pedicle, whereas the arrow intending to label the thrombosed internal jugular vein is on the left spinal transverse process (see Figure 1)	R & E	CM & EV	N
3	MRI	L	Arrow intending to highlight increased signal in the spinal cord points to the posterior longitudinal ligament.	R & E	CM & EV	N
4*	US	L	Text indicates ''that the right ovary was not identified,'' yet annotation visible on the image is ''sag rt ovary'' with ovarian tissue seen	R	EV	N
5**	CT	L	Subcutaneous emphysema is labeled as a pneumothorax, whereas the visible pneumothorax is not labeled	R	CM & EV	N
6**	CT	D	Right pleural effusion is present but not described	E	CM & EV	N
7***	CT	L	Arrow intending to label the right kidney points to perinephric fat (see Figure 2). The right kidney is not visible on the image.	R	EV	N
8***	CT	D	Sentinel clot adjacent to a ruptured aortic aneurysm is not described. Sentinel clot aids in localization of the site of hemorrhage on CT (see Figure 2).	R	CM & EV	N
9	CT	D	Subcutaneous emphysema is present but not described	R	EV	N
10†	XR	D	Subcutaneous emphysema is present but not described	R	EV	N
11††	CT	D	Enhancing collateral vessels are not indicated as a secondary finding of central venous occlusion	R	CM & EV	N
12††	CT	D	Image description describes absence of filling in the brachiocephalic vein when this vein is not present on the image	R	EV	N
13	A	D	Arterial dissection or thrombus proximal to an intra-arterial foreign body is not described	R	NS	N
14‡‡‡	XR	D	Loss of the psoas shadow not described on abdominal plain film. This finding suggests the diagnosis of retroperitoneal hemorrhage/mass.	R	CM & EV	N
15	XR	D	Ill-defined superior-lateral border of a round upper lung zone opacification is not described. This finding localizes the mass to be pleural or abutting the pleura as opposed to intrapulmonary.	R	NS	N
16†††	XR	D	Chest XR post–Heimlich valve insertion does show the partly collapsed bulla but neglects to mention the pneumothorax visible	R	CM & EV	N
17‡	CT	D	CT post–Heimlich valve insertion with partly collapsed bullae. A pneumothorax is also present but not described.	R	CM & EV	N
18	MR	D	MRA describes the presence of an intramural thrombus when absent flow is all that can be appreciated on this type of study	R	NS	N
19	XR	D	Chest XR describes a spine fracture and hemopneumothorax, which are not visible on the image provided	R & E	CM & EV	N
20‡‡	CT	D	Aortic dissection is described, although no intimal flap is presented, a finding essential for differentiating dissection from thrombus or intramural hematoma	R	NS	N

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Table 3. Continued

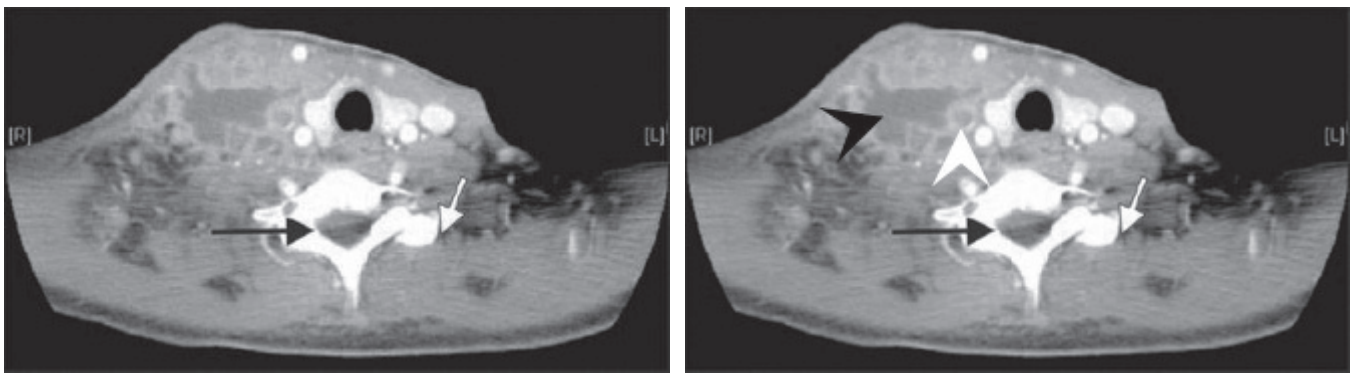
Error #	Modality	Error type	Description	Detected by	Significance	Radiology (Y/N)
21	US	D	Endovaginal ultrasound image of a patient with ectopic pregnancy; the bladder and empty uterus are well labeled. Echogenic mass between the rectum and uterus (possibly representing hemorrhage) is not described.	E	CM & EV	N
22	XR	D	Chest XR as presented is overexposed, so the clear lungs described in the text cannot be seen in the radiograph	E	CM & EV	N
23	CT	D	Head CT scan in a patient with mixed-density bilateral subdural hematomas. The mixed-density serum cell level was neither identified nor labeled.	R & E	CM & EV	N

A = angiography; CM = clinical management; CT = computed tomography; D = error description; E = emergency physician; EV = educational value; L = errors of labeling; MR = magnetic resonance; MRA = magnetic resonance angiogram; N = no; NS = not significant; R = radiology; US = ultrasonography; XR = x-ray; Y = yes.
Symbols (*, †, and ‡) are used to identify images where more than one error or ''underlabeling'' was present, with a unique symbol for each image. The same group of symbols are used consistently between Table 3 and Table 4.

system requiring multiple caregivers, communication is vital to successful patient care and is one of the qualities listed as an essential competency in medical education. This relates not only to the verbal but also the written word, including medical journals.

Emergency medicine in Canada is practiced by a very heterogeneous group of physicians. This includes family practitioners, emergency physicians trained through the Canadian College of Family Physicians [CCFP(EM)], and the Royal College of Physicians and Surgeons emergency specialists (FRCPC). In addition, emergency physician responsibility in reading imaging studies varies across the country. Although emergency physicians often provide a preliminary clinical interpretation on a plain film at the time of patient care, this is usually not the case for CT, ultrasonography, or MRI. Two common exceptions to this are emergency department ultrasonography and after-hour CT head interpretation in many centres. The targeted readership of *CJEM* is therefore a very diverse group in terms of training, experience, and responsibility for clinical interpretation of imaging studies.

A final published article is a compromise between complete medical information and a concisely written manuscript. This often requires distilling complicated study designs or patient histories down to a relatively brief and succinct manuscript. It is necessary to highlight important aspects of the presented material while simultaneously providing an intellectually stimulating yet readable paper within the space requirements set by the journal. Although it is recognized that these limitations may make it difficult to include all



A B

Figure 1. *A*, Contrast-enhanced axial computed tomographic image of the neck as originally published. The original caption read, ''The black arrow indicates the multiloculated abscess. The white arrow indicates the right internal jugular vein with a tiny ring of contrast around the occluding thrombus.'' A translation of the arrows has occurred, shifting them markedly posterior and to the left from their intended structures. Reproduced with permission from Barnett and Medzon.[2] *B*, If the translation were reversed, the arrows would be accurate. A *white arrowhead* points to the actual location of the right internal jugular vein and a *black arrowhead* to a multiloculated abscess. The reviewing emergency physicians indicated that this labeling error could have affected both clinical management and educational value. This image is summarized in Table 3, error 2.

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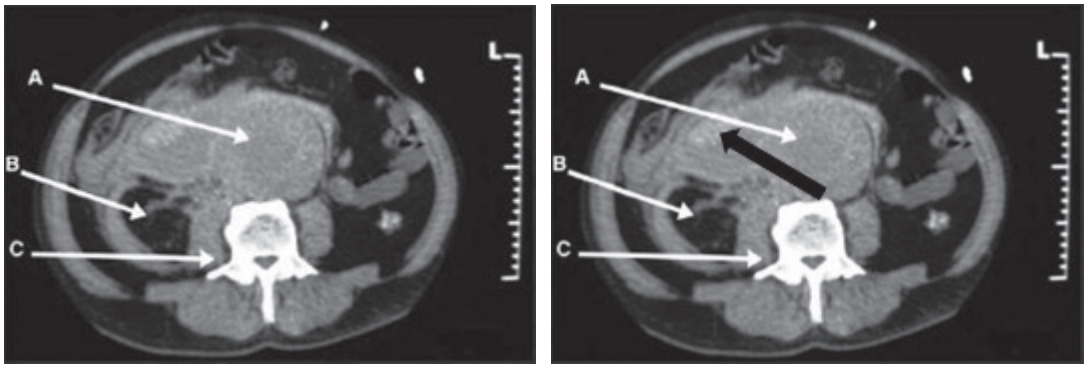

A **B**

Figure 2. *A,* An unenhanced axial computed tomographic (CT) image of the abdomen as originally published. The original caption read, ''A CT scan showing a large 9-cm infrarenal aortic aneurysm extensively leaking around the right kidney and psoas muscle. A = ruptured abdominal aortic aneurysm; B = right kidney; C = right psoas muscle surrounded by blood.'' The kidney is not visible on this image, and the original arrow ''B'' is pointing to perinephric fat. Reproduced with permission from Vaidyanathan et al.[3] *B,* The same image with the sentinel clot material labeled (*black arrow*). Neglecting to highlight the sentinel clot was identified by radiologists as an error of description as this is a pertinent positive finding present on the image that helps identify the site of bleeding. Reviewing emergency physicians indicated that the labeling error affected educational value, whereas the description error could have affected clinical management and educational value. This image is summarized in Table 3, errors 7 and 8.

relevant information regarding radiologic images, we hope that authors strive to present relevant descriptions and accurate labeling of all images. Determining if an error could potentially have changed clinical management is difficult as that judgment was made on the facts as presented limited to the figures and description provided. This is obviously an artificial scenario; however, it was included as a way of determining if the errors were significant to both clinical practice and educational value. Of the 23 errors detected, 18 (78%) were rated as potentially affecting clinical management, educational value, or both.

Although there are obvious differences between a patient chart or radiologic report and a publication with figure description, similarities can be drawn. A radiologist's report is written with the intent of being a concise, accurate, consistent, well–organized, and complete reporting of radiologic findings.[4,5] This finding is validated by Johnson and colleagues, who published the results of their survey regarding what qualities of a radiologist's report are valued most by physicians.[6] They found that accuracy was considered most important and noted that clarity, completeness, conciseness, and mentioning pertinent negatives were other highly valued attributes.[6] It is reasonable that similar objectives be the aim for published images and their descriptions.

In the current review, we categorized common errors in reporting into two main areas: inaccurate labeling and poor textual description of the presented image. An additional category of ''underlabeled'' was also added by the emergency physician reviewers. Numerous authorship guidelines are available to help authors avoid these pitfalls, often through the individual journals section for authors on their web page, including the *CJEM*.[7] Other valuable resources include articles dedicated to writing scientific papers. These may range from very broad to highly specific. Focusing on images that are published, one should keep in mind that the image should clearly illustrate the important findings, use plenty of well-positioned arrows, provide text that concisely summarizes the major points, and ensure that images of high visual quality are selected.[8,9] Our review of the *CJEM* images suggests that authors must ensure that pertinent findings visible on the image are described in the text and, conversely, that all findings described in the text are visible on the selected image. Attention to these details by authors would significantly increase the accuracy of their published images, enhancing the quality of their article. Additionally, more liberal use of labels would help the targeted readership of the *CJEM* gain the most benefit during reading for medical education.

Another opportunity to improve the quality of published images would be consultation with a specialist in the field who may identify errors previously missed. All of the image errors were found in articles without official radiologist involvement. In

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Table 4. Description of images where additional labeling would have enhanced educational value

Image #	Modality	Description	Radiology (Y/N)
1*	US	Sonogram of right ovarian torsion describing a solid and cystic mass posterior to the bladder. Arrows or use of the calipers on the image would enhance EV.	N
2†	XR	Chest XR correctly described as having pneumothoraces and pneumomediastinum. Arrow identification would help EV.	N
3††	CT	Patient with thrombosed SVC. Arrows to highlight the relevant anatomy would increase EV.	N
4†††	XR	XR showing the partly collapsed bulla with Heimlich valve. Arrow identification would help EV.	N
5‡	CT	CT post–Heimlich valve insertion with partly collapsed bullae. Arrow identification of the bullae would help EV.	N
6‡‡	CT	Image shows mural thrombus in what is presumed to be an aortic dissection. Labels would enhance EV.	N
7‡‡‡	XR	Abdominal XR in patient with ruptured aortic aneurysm described the aortic calcification. Arrows would increase EV by showing this subtle finding.	N
8	XR	Case of neoplastic lesion of the mandible. Arrows nicely show the lytic lesions, although the inferior alveolar canal is not labeled, making it difficult to separate this normal structure from the lesions.	N
9	CT	Text describes fluid around both the spleen and liver, although the arrows point only to the fluid around the spleen	N
10	XR	Chest radiograph reveals a left pneumothorax with mediastinal shift to the right. The pneumothorax findings were subtle and would have benefited from identification with arrows.	N
11	XR	Intramural bowel gas described. Although present, these findings are tough to separate from normal bowel gas and would have benefited from arrow identification.	Y
12	CT	Same as for XR findings above (see image 11)	Y
13	CT	Same case as above (see images 11 & 12). Labels to identify the normal bowel may have helped EV.	Y
14	XR	Patient with cardiac herniation where the unusual mediastinal contours and pneumomediastinum are well described. Arrows would significantly enhance EV.	N
15	XR	Patient with diaphragmatic rupture and gastric herniation where the figure description states ''clearly showing left diaphragmatic rupture…'' Arrows would help EV.	N
16	XR	Spontaneous pneumothorax with collapse of right lung. Although findings are visible, arrows would increase EV.	N
17	CT	Stroke patient. Arrows to identify the dense middle cerebral artery anatomy would help EV.	N
18	CT	Case of orbital pseudotumor where findings are well described. Identification with arrows would help EV.	N
19	XR	Arrow identification of the cervical rib would help EV	N
20	CT	Abdominal CT scan of a ruptured abdominal aortic aneurysm. Arrows to highlight the aneurysm and hematoma will help EV.	N
21 & 22 (2 images)	US	Sonogram showing guidewire being introduced into the internal jugular vein would have been better illustrated by having arrows point out its more proximal aspect	N
23	CT	Chest CT scan showing bullae with mediastinal shift where the bullae and septae are well described. Arrow identification would help EV.	N
24	XR	XR showing an apical bulla masquerading as a pneumothorax. Arrow identification would help EV.	N
25	XR	XR showing the partly collapsed bulla with Heimlich valve. Arrow identification would help EV.	N
26‡	CT	CT showing bullae. Arrow identification would help EV	N

A = angiography; CT = computed tomography; EV = educational value; N = no; SVC = superior vena cava; US = ultrasonography; XR = x-ray; Y = yes.
Symbols (*, †, and ‡) are used to identify images where more than one error or ''underlabeling'' was present, with a unique symbol for each image. The same group of symbols are used consistently between Table 3 and Table 4.

addition, the majority of errors were detected by radiology alone (15 of 23), with 5 detected by both radiologists and emergency physicians and 3 by emergency physicians alone. Of the images detected by radiologists alone, 6 may have affected both clinical management and 5 would have affected educational value, whereas 5 were felt to be trivial. This type of expert consultation has been described as ''mandatory for first time authors.''[10] Although we did not assess author experience, the rate of errors in published images suggests that this may apply to all authors, especially when dealing with areas of medicine beyond their scope of expertise. This consultation could range from an informal discussion of the case with possible acknowledgement in the manuscript to the formal inclusion of the consultants as an author.

The review process is another possible site of intervention. When evaluating a radiologic image,

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the reviewer needs to decide if the image submitted is of a high-enough quality, applicable to the case presented, and paired with an accurately written caption.[9,11] Given the relative frequency of radiologic errors, the *CJEM* may benefit from having dedicated radiologist reviewers comment on images and their descriptions as part of the review process. Review of the actual final images by a radiologist prior to publication might also help avoid the mislabeling issues associated with translation of arrows.

This article does have several limitations. The review of only one journal is a limitation. Interpretation of image accuracy could be considered a subjective endeavour and introduces interobserver variability as a possible source of error. When also considering the unique characteristics of manuscript publication versus radiologic reports, there is no easy gold standard for what constitutes an error. Subjectivity of necessary information to include in published manuscripts makes the "errors of omission" reported particularly subject to controversy and discussion. Although there may have been benefits to independent review of the images with subsequent comparison of interpretation via kappa statistics, we chose using a consensus opinion of two radiologists to both maximize error detection and allow for discussion to determine if the errors are significant. A similar approach was used by the emergency physicians reviewing the images. Another limitation is that we only assessed inclusion as an author as the only form of radiologist involvement. This will obviously overlook collaboration with authors, where the radiologist involvement is informal and perhaps not significant enough to warrant inclusion as an author.

CONCLUSIONS

Radiologic images published in the *CJEM* are generally of high quality; however, 26% of images reviewed were found to contain errors. Checking the accuracy of labels and ensuring congruency between text descriptions and images provided would substantially reduce the number of errors published regarding radiologic images. This responsibility is shared by both authors and reviewers. Radiologist involvement in the publication and review process may be of assistance in reducing the number of errors published.

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