Original Article

The Appropriate Use of Conventional Abdominal Radiographs and Its Usefulness in Non-Traumatic Acute Abdomen Patients

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Abstract

Objective: Conventional abdominal radiographs (CAR) are often ordered in patients presented with acute abdominal pain. We investigated the appropriate use of CAR and its usefulness in the Emergency Department (ED).

Methods: Adult patients who had CAR ordered from ED between 1st September and 31st October 2018 were retrospectively reviewed. Patients' demographics, indications for CAR, CAR results, further imaging, and their results, and final diagnoses were assessed. The appropriate or inappropriate use of CAR was stratified. A comparison between the appropriate group and inappropriate group was made.

Results: There were 154 CAR studies, M:F = 57:97, mean age 48.3 years (ranged 15 - 88 years). 33.8% of CAR was considered an appropriate use. Of the 154 examinations, 17 (11%), 73 (47%), and 64 (42%) were reported as positive, negative, and non-diagnostic results by CAR respectively. A comparison between appropriate and inappropriate groups, number of cases, CAR negative results, CAR non-diagnostic result, and negative further imaging results were significantly different. There was no statistical difference in the number of further imaging between both groups. The common findings of positive results that had no further imaging were bowel obstruction (n = 6), followed by bowel perforation (n = 3). 12 out of 73 (16.4%) negative CAR results, and 11 out of 64 (17%) of non-diagnostic results had positive findings from further imaging.

Conclusion: The appropriate use of CAR in non-traumatic acute abdomen patient in our institution is only 33.8%. More precise imaging is required to make a decision whether appropriate indication or not. Strict to the protocols, staff education and internal audit should be performed in the hospital.

Keywords: Abdominal radiograph, Acute abdominal pain, Appropriateness criteria, Imaging

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Introduction

Acute abdominal pain is one of the major causes of the patients presented to the emergency department and most of this condition require imaging. Conventional abdominal radiographs (CAR) either 3-view acute abdomen series or 2-view plain abdomen series are usually an initial imaging modality because they are widely available at a low cost. However, literature has demonstrated that CAR has limited diagnostic value for assessing acute abdominal pain.[1, 2, 3] Modern imaging modalities have replaced CAR as initial imaging in some specific clinical spectrum[4] but the cost and feasibility are concerned. The revised appropriateness criteria in 2018 by the American College of Radiology (ACR Appropriateness Criteria®) suggests computed tomography (CT) as initial imaging in many clinical scenarios of acute abdominal pain.[5] However, the CAR is often ordered by the clinicians. A survey in medical students and interns showed that almost 80% of them have never heard of the ACR Appropriateness Criteria®.[6, 7] A large survey in emergency medicine residents by Dym et al. found that emergency medicine residents were able to choose the most appropriate examination in the average score of 71% whereas the expected score should be close to 100%.[8] Another article demonstrated that only 2.4% of a physician in their study used ACR Appropriateness Criteria® to determine a proper imaging technique for a patient's clinical problem.[9]

This study is aimed to investigate the appropriateness use of CAR at a single institution of non-university, teaching hospital, and the rate of findings of CAR in both appropriate and non-appropriate use groups, and to compare the findings between both groups.

Patients and Methods

This study was approved by our University Review Board Committee, No.30/2562. The inform consent was waived by the retrospective nature. The study was conducted at an urban, non-university teaching hospital in a district that is about 100 km far from the capital of Thailand. The Emergency Department services about 57,000 patients a year.

The Radiology Information System during the months of September and October 2018 was retrospectively reviewed. All adult patients, aged more than 14 years old who had CAR, either 3-view acute abdomen series or 2-view plain abdomen series which were ordered from the ED were included. Initial assessment and management, as well as the decision to imaging, were mostly performed by a novice physician who rotates through the hospital every year.

Patients' demographics, management, further imaging within the same day or the following day, and final diagnosis were assessed by the inspection of the patients' records from the Hospital Information System. The final diagnosis was determined using operative findings, pathologic reports, or discharge diagnoses in those not undergoing an operation.

We defined the appropriateness use of CAR by relating to the RCR guidelines[5] and other studies[10, 12] (Table 1).

Table 1 Appropriate and Inappropriate indications for abdominal radiographs

Appropriate	Inappropriate
Bowel obstruction	Appendicitis
Bowel perforation	Biliary disease
Peritonitis	Pancreatitis
Exacerbation of colitis	Abdominal mass
Foreign body	Constipation
Renal calculus/renal colic	Gynecologic conditions
	Urinary tract infection
	Gastrointestinal bleeding

CAR results were classified to a positive result, a negative result, and a non-diagnostic result. A positive result was defined when the x-ray reported as following: bowel obstruction, bowel perforation or free air, abnormal calcification that related to patient's clinical, soft tissue mass, presence of ascites or acute opaque foreign body. A negative result was defined when the conclusion in the report stated as following: normal or negative finding, unremarkable study. When the report mentioned the terms including adynamic ileus, maybe, cannot be excluded, it was defined as non-diagnostic results. The further imaging results were also classified as a positive result, a negative result, and a non-diagnostic result.

Patients whose ages below 15 years old, had no available clinical information or no CAR report or presented with abdominal trauma were excluded.

We calculated the percentage of total CAR orders according to the appropriate use or inappropriate use and stratified the results of the CAR in each group. Data were analyzed using R (version 3.0) and SPSS (version 25) program. Chi-square goodness of fit and Binomial exact test were used to assess the differences between appropriate and inappropriate indications in each test. The differences in the number of each gender between each group were assessed using the Chi-square test of independence. The effect of age and gender on the indication was investigated using binary logistic regression. The $P < 0.05$ was considered statistically significant.

Results

There were 154 CAR examinations that fulfilled the criteria during the studying period. Four patients had discontinuous two examinations. The mean patient age was 43.8 years with a range of 15-88 years, consisting of 57 males and 97 females. Fifty-two examinations (33.8%) were considered appropriate use of CAR. The number and indications for CAR stratified by appropriate and inappropriate indications are shown in Table 2. Dyspepsia, localized pain, pancreatitis, gastroenteritis, and acute appendicitis were among the most common inappropriate indications and comprised of 83% of inappropriate use of CAR. Figure 1 demonstrates a comparison of the frequency of the CAR results with appropriate and inappropriate indications. The results of CAR and further imaging with their corresponding results are illustrated in Figures 2 and 3.

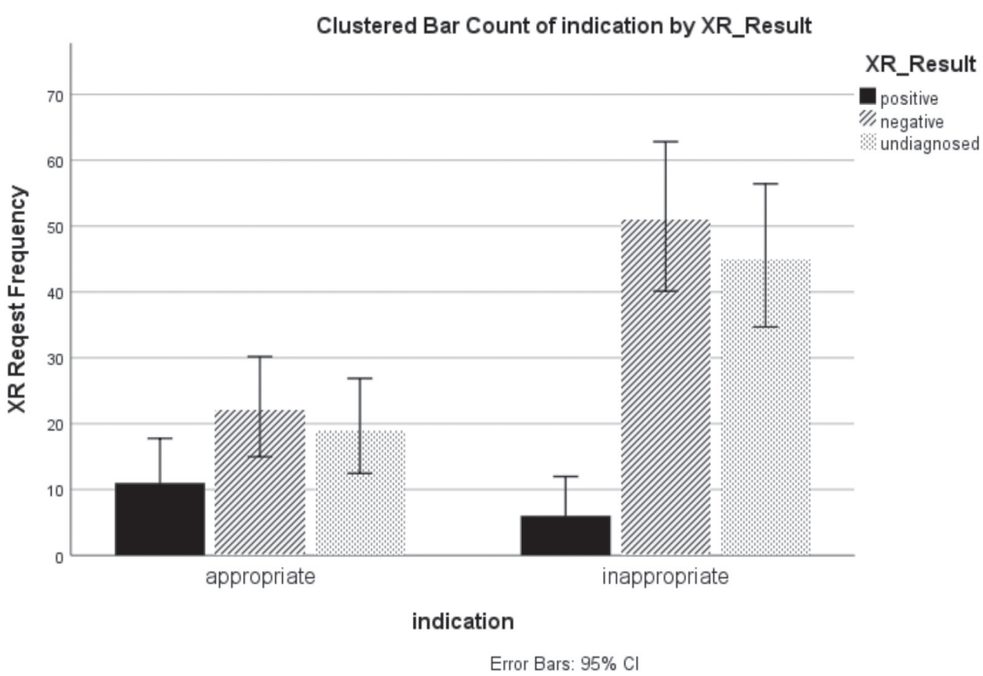

Figure 1 Comparison of frequency of the CAR results with appropriate and inappropriate indications.
*XR = X-ray

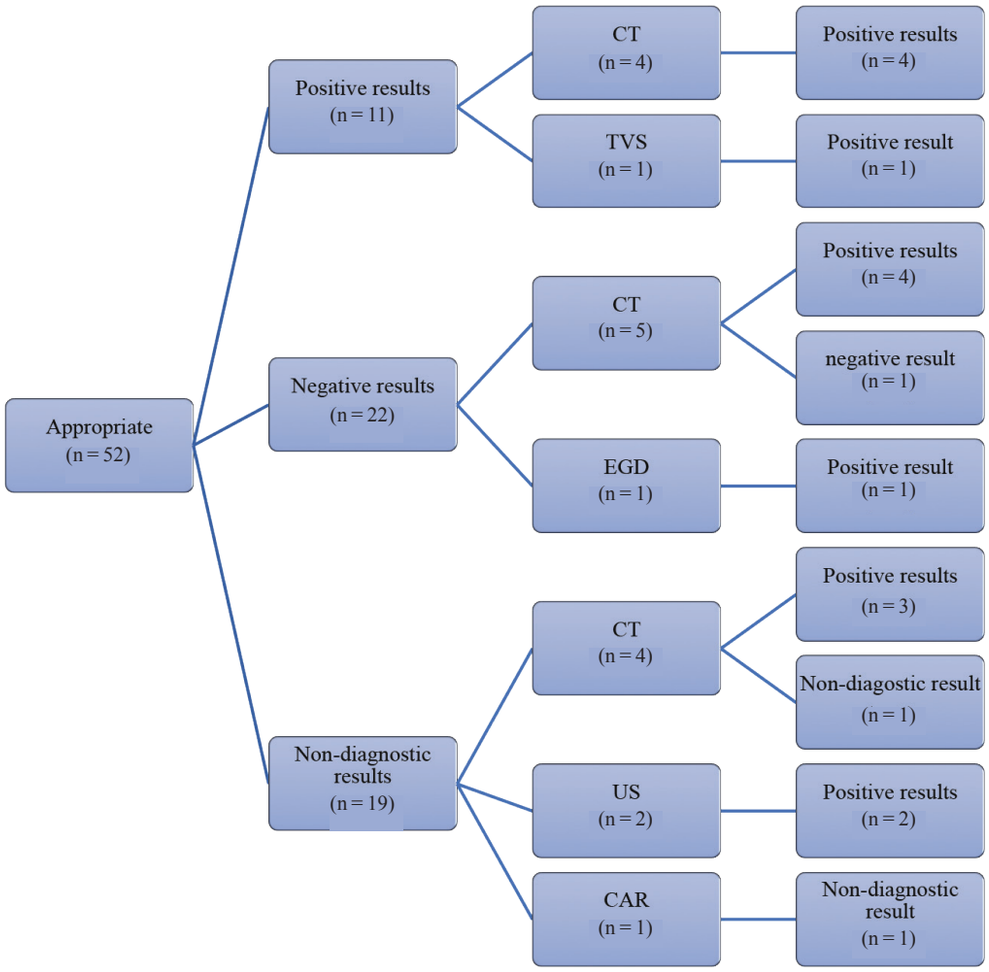

Figure 2 Diagram reveals further imagings and results in appropriate indication group.
*CT = computed tomography, *TVS = transvaginal ultrasound, *EGD = esophagogastroscopy, *US = ultrasound, *CAR = conventional abdominal radiographs.

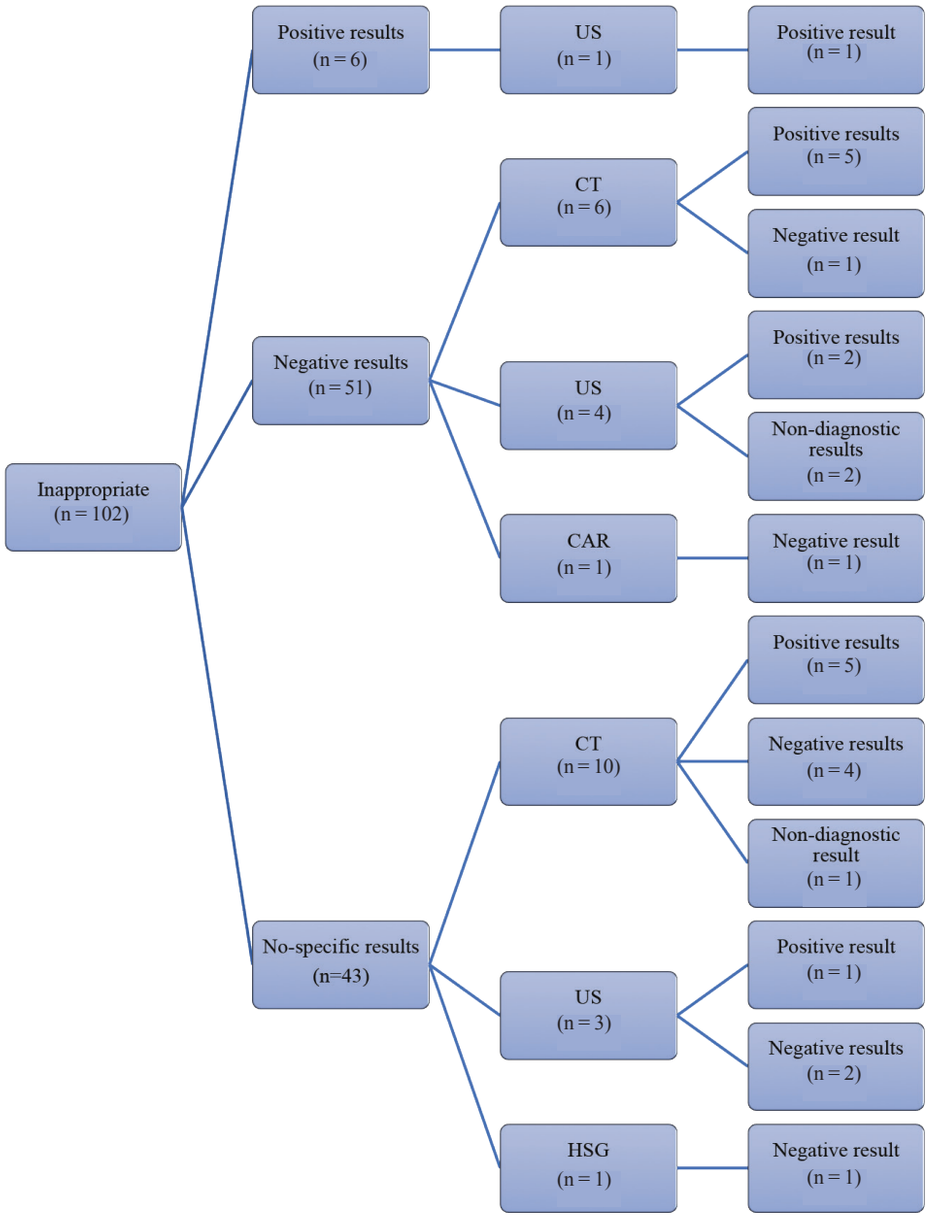

Figure 3 Diagram reveals further imaging and results in inappropriate indication group.
*US = ultrasound, *CT = computed tomography, *CAR = conventional abdominal radiographs, *HSG = hysterosalpingography.

Table 2 Distribution of clinical diagnosis warranting conventional abdominal radiographs stratified by appropriate indications or inappropriate indications

Appropriate (n = 52)		Inappropriate (n = 102)	
Diffuse abdominal pain	21 (40.4%)	Dyspepsia	24 (23.5%)
Bowel obstruction	16 (30.8%)	Localized pain	22 (21.6%)
Peritonitis	6 (11.5%)	Pancreatitis	17 (16.7%)
Inguinal hernia	4 (7.7%)	Gastroenteritis	11 (10.8%)
Advanced cancer	2 (3.8%)	Appendicitis	11 (10.8%)
Bowel perforation	1 (1.9%)	Gastrointestinal bleeding	7 (6.9%)
Chemical ingestion	1 (1.9%)	Thoracic disease	6 (5.9%)
Post-op complication	1 (1.9%)	Abdominal mass	2 (2%)
-		Ascites	1 (1%)
-		Anuria	1 (1%)

Differences between indications

Differences between appropriate indications and inappropriate indications are represented in Table 3. There were statistical differences among age between appropriate group and inappropriate group (data were transformed using square root transformation sqrt (x+1); independent sample t-test; t152 = 2.300, P = 0.023), but no significant difference in gender between groups (χ^2 test of independence; χ^2 (1) = 0.383, P = 0.598). The appropriate indication group significantly differed from the inappropriate indication group in number of cases (χ^2 goodness of fits; χ^2 (1) = 16.234, $P < 0.001$), CAR negative results (χ^2 goodness of fits; χ^2 (1) = 11.521, P = 0.001), CAR non-diagnostic result (χ^2 goodness of fits; χ^2 (1) = 10.563, P = 0.002) and negative further imaging results (χ^2 goodness of fits; χ^2 (1) = 6.400, P = 0.021). No significant difference in the appropriate and inappropriate indication groups in CAR positive results (χ^2 goodness of fits; χ^2 (1) = 1.471, P = 0.332), number of further imaging cases (χ^2 goodness of fits; χ^2 (1) = 1.455, P = 0.291), CT cases (χ^2 goodness of fits; χ^2 (1) = 0.310, P = 0.711), US cases (χ^2 goodness of fits; χ^2 (1) = 2.273, P = 0.227), other imaging cases (binomial exact test; P = 0.500), positive further imaging results (χ^2 goodness of fits; χ^2 (1) = 0.034, P = 1.000) and non-diagnostic further imaging results (Binomial exact test; P = 1.000) were observed.

Table 3 Differences between appropriate indications and inappropriate indications

	Appropriate	Inappropriate	*P*
Number of cases	52 (33.8%)	102 (66.2%)	< 0.001
Age (Mean(SD)), yrs	48.1 (18.2)	41.6 (17.1)	0.023
Gender			
- Female	31 (59.6)	66 (64.7)	0.536
- Male	21 (40.4)	36 (35.3)	
Conventional abdominal radiograph results			
- Positive	11 (21.2%)	6 (5.9%)	0.332
- Negative	22 (42.3%)	51 (50.0%)	0.001
- Non diagnostic	19 (36.5%)	45 (44.1%)	0.002
Number of further imaging	18 (34.6%)	26 (25.5%)	0.291
- Computed tomography	13 (72.2%)	16 (61.5%)	0.711
- Ultrasound	3 (16.7%)	8 (30.8%)	0.227
- Others	2 (11.1%)	2 (7.7%)	0.500
Results of further imaging			
- Positive	15 (83.3%)	14 (53.9%)	1.000
- Negative	1 (5.6%)	9 (34.6%)	0.021
- Non diagnostic	2 (11.1%)	3 (11.5%)	1.000

Effect of age and gender

Gender of participants did not have a significant effect on indication (binary logistic regression; χ^2 (1) = 0.034, P = 0.854). However, age of participant significantly predicted the appropriateness of indication (binary logistic regression; b ± se = -0.021 ± 0.01, χ^2 (1) = 4.577, P = 0.032) by which the likelihood of inappropriate indications decreased 2.1% regarding one year increase in age of participant (OR = 0.979, 95% CI = (0.960, 0.998)).

Positive result

Of the 154 examinations, 17 (11%) were reported positive by CAR. However, 6 of them (35%) had further imaging which was CT (n = 4) and US (n = 2). The results from CT were bowel obstruction in 3, bowel perforation in 1, carcinomatosis peritonei in 1, and from the US were rectal perforation in 1 and tubo-ovarian abscess in 1. The findings of positive results which had no further imaging were bowel obstruction (n = 6), followed by bowel perforation (n = 3), ascites (n = 2), and mass (n = 1).

Negative result

Seventy-three out of 154 patients (47%) had negative reports from CAR. Further imaging was performed in 17 patients (23%) and positive results which were received from CT (n = 8), US (n = 3), and gastroscope (n = 1) were shown in 12 patients (12 of 73, 16.4%). The results included acute pancreatitis (n = 2), acute cholecystitis (n = 2), CBD obstruction (n = 2), and the other 6 various abnormalities (n = 1 each) included hydronephrosis, hepatocellular carcinoma, tubo-ovarian abscess, acute appendicitis, epididymo-orchitis, and erosive gastritis.

Non-diagnostic result

The CAR results were non-diagnostic in 64 patients (42%). Of these, 21 patients (33%) were subjected to further imaging which demonstrated an abnormality in 11 patients (11/64, 17%). Among these abnormalities, CT was used more often than the US (8:3). The findings from CT were bowel obstruction (n = 3), carcinomatosis peritonei (n = 2), and the other 3 various abnormalities (n = 1 each) included bowel perforation, ventral hernia,

and acute appendicitis whereas ureteric obstruction, epididymo-orchitis, and acute pancreatitis were the abnormal findings shown by the US.

Discussion

CAR has shown to have limited values in the evaluation of acute abdominal pain for years.[1, 2, 3, 4] In line with our findings that only 11% positive results were achieved from CAR as well as the high percentage of non-diagnostic results that were 42%. A wide range of 12-68% of non-diagnostic results has been reported in the literature.[3, 12, 13] Twenty-three percent of our patients underwent further imaging in spite of negative CAR results and 16.4% of them were abnormal including hydronephrosis, hepatocellular carcinoma, tuboovarian abscess, acute appendicitis, epididymo-orchitis, and erosive gastritis. This is a good agreement with the observations obtained in the literature that CAR had 0% sensitivity for the detection of these abnormalities.[13] The most common findings that did not require further imaging in this study were bowel obstruction and a bowel perforation. Nevertheless, 4 out of 6 cases had further imaging for more precision of the causes that is a current trend.[14, 15] Three cases of bowel obstruction and a case of bowel perforation could not be diagnosed by CAR and were reported as a non-diagnostic result in the present study. In line with data in the literature that CAR had 49% sensitivity for bowel obstruction[13] and 50-70% for bowel perforation.[16]

The findings in our study also showed a high rate of inappropriate use of CAR (66.2%) in concordance with prior studies which ranged between 25 - 68%.[11, 12] Though inappropriate indications, further imaging was performed in 25.5% in the present study which was no statistical difference compared to the appropriate indication group and significant findings were found in 53.9%. Besides, when the indications for CAR were inappropriate, the results of CAR which were negative or non-diagnostic were significantly higher than the appropriate indications. The result of further imaging in this group was also negative significantly. Moreover, inappropriate use of CAR and further imaging added radiation to the patients, delayed management and increased cost. The five most common inappropriate use of CAR in the current study were dyspepsia, localized pain, pancreatitis, gastroenteritis, and acute appendicitis. Other imaging modalities have proved to replace CAR in many conditions. For example, CT is the first imaging modality for acute appendicitis.[17, 18] Non-contrast CT of the abdomen and pelvis is used in the patient with renal colic.[19] CT angiography is suggested when acute mesenteric ischemia is suspected.[20] US is usually performed firstly in the patient with right upper abdominal pain, and suspicious of acute cholecystitis.[21] CAR is useful in the setting of intra-abdominal foreign body that has demonstrated 90% sensitivity in the literature.[13] However false negative can occur when the foreign body is not opaque.[22]

Low-dose non-contrast CT has proved to have a significant advantage in accuracy compared to CAR with minimal addition radiation to the patient.[23] A little observation was obtained in this study that the inappropriate use of CAR decreased when the age increased. This may be postulated by older people usually have a more significant disease than the younger.

Limitations

This is a single-institution research. Different kinds of hospitals such as a university hospital or a rural hospital may show different results. Some hospitals do not allow the junior doctors to order advanced or high-cost imaging, because of their economic strategy. The US may not be available in an off-hour period, and CAR is obligated. Further discrimination research between office-hour and off-hour periods should add more benefits. We did not investigate the effect of the level of doctor's experience on the decision to the type of imaging. The less experienced doctor may use inappropriate imaging than a more experienced doctor. However, this study was conducted in the real-life situation in which the novice doctors work in the emergency room.

The results demonstrated that physicians in the emergency department still ordered CAR in spite of its little value in the acute abdominal pain setting. Either appropriate or inappropriate indication, more precise imaging was performed. Inappropriate order of CAR results in delayed management, added cost as well as radiation dose. Development of protocols, staff education, and internal audit are suggested to reduce the inappropriate use of CAR.

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Potential conflict of interest

All authors have no conflict of interest to disclose.

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