Meta-Analysis

The Diagnostic Accuracy of Apparent Diffusion Coefficient Values in Detecting Malignant Lung Lesion Using Histopathology as the Reference Standard

Methodology

This document provides the results of meta-analysis conducted to synthesize the results of various research studying the diagnostic accuracy of apparent diffusion coefficient (ADC) values derived by diffusion-weighted MRI in detecting malignant lung lesions using surgical histopathology or biopsy results. Random effects model was used since each study was conducted independently violating the assumption of the fixed model having a common true effect size and each study used different levels of threshold value. In the provided results below, five separate meta-analyses were made to synthesize the values collected from 8 studies identified – one each for sensitivity, specificity, positive predictive value, negative predictive value, and accuracy. The contingency table values for each study was derived from their reported diagnostic measures.
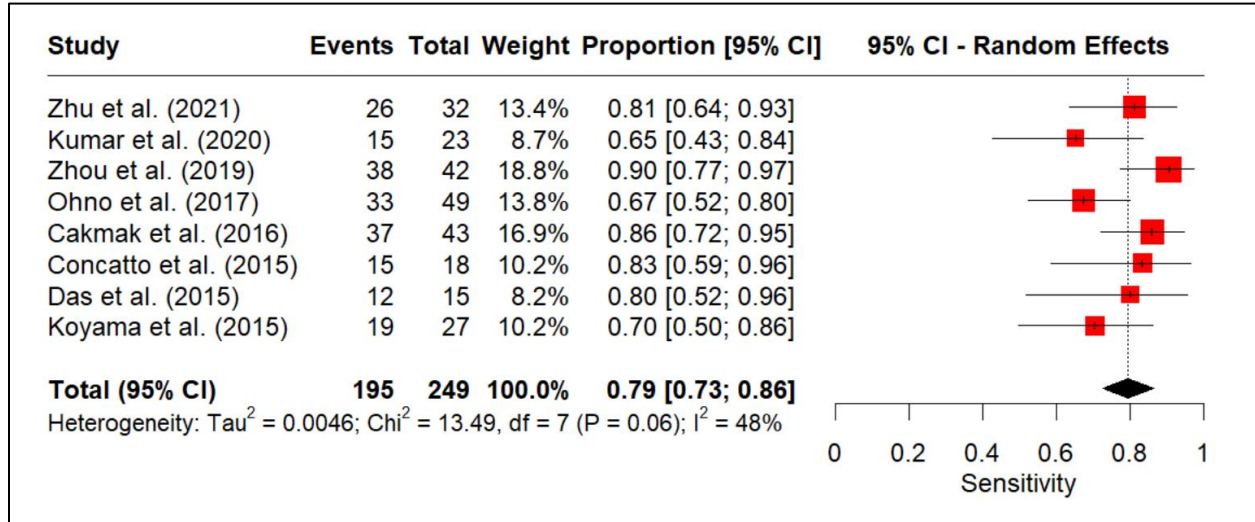
Pooling of Diagnostic Measures

In meta-analysis, forest plot is being used to easily visualize individual and summary effect sizes. To help you be guided in making sense of the plot, you should know of the following pieces of information:

1. The size of each box represents the weight given in computing the summary effect. Studies with larger boxes were given more weight in computing the summary effect since they are deemed to be more precise than others.
2. In the plot, precision can be easily seen through the length of the confidence interval. The shorter the interval, the higher the precision of the results. High precision means lower standard error.

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Study	Events	Total	Weight	Proportion [95% CI]	95% CI - Random Effects
Zhu et al. (2021)	26	32	13.4%	0.81 [0.64; 0.93]	
Kumar et al. (2020)	15	23	8.7%	0.65 [0.43; 0.84]	
Zhou et al. (2019)	38	42	18.8%	0.90 [0.77; 0.97]	
Ohno et al. (2017)	33	49	13.8%	0.67 [0.52; 0.80]	
Cakmak et al. (2016)	37	43	16.9%	0.86 [0.72; 0.95]	
Concatto et al. (2015)	15	18	10.2%	0.83 [0.59; 0.96]	
Das et al. (2015)	12	15	8.2%	0.80 [0.52; 0.96]	
Koyama et al. (2015)	19	27	10.2%	0.70 [0.50; 0.86]	
Total (95% CI)	**195**	**249**	**100.0%**	**0.79 [0.73; 0.86]**	

Heterogeneity: $Tau^2 = 0.0046$; $Chi^2 = 13.49$, df = 7 (P = 0.06); $I^2 = 48\%$

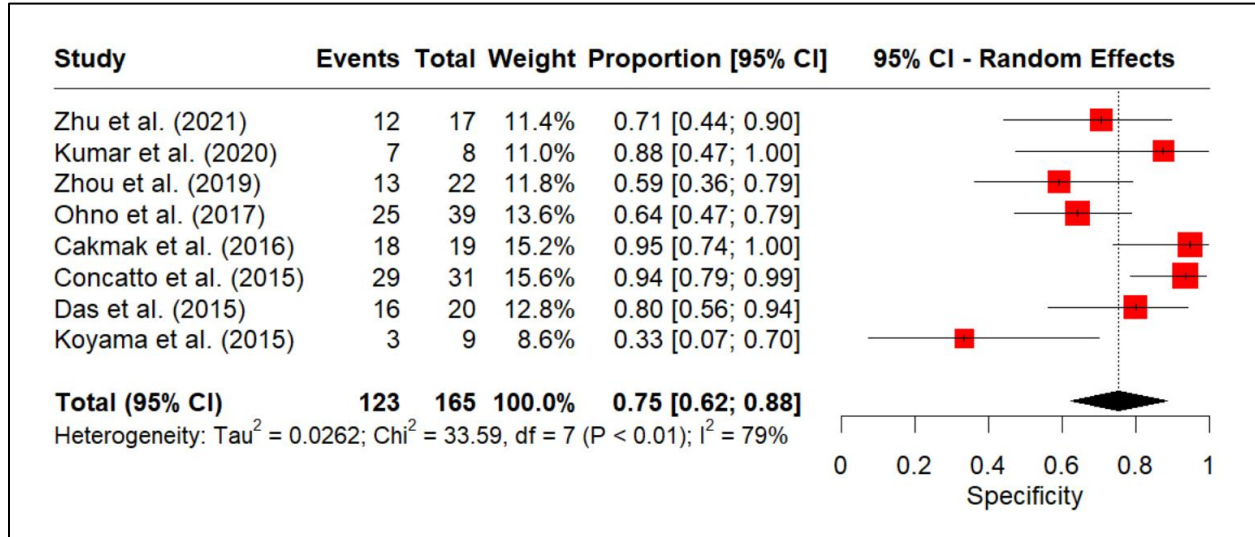*Events = TP, Total = TP + FN*

Figure 1. Random Forest Plot of Reported and Pooled Sensitivities

Random forest plots shows that the calculated pooled sensitivity is 0.79. This shows that in summary, the apparent diffusion coefficient (ADC) values derived by diffusion-weighted MRI correctly identify malignant lung lesions using surgical histopathology or biopsy results 79% of the time. Consequently, 21% of the time, ADC values will identify true malignant lung lesions as benign.

In synthesizing the results, the weight given to studies were fairly distributed – with weights mostly around 10-19% each. This implies that no study extremely influenced the pooled value than the others.

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Study	Events	Total	Weight	Proportion [95% CI]	95% CI - Random Effects
Zhu et al. (2021)	12	17	11.4%	0.71 [0.44; 0.90]	
Kumar et al. (2020)	7	8	11.0%	0.88 [0.47; 1.00]	
Zhou et al. (2019)	13	22	11.8%	0.59 [0.36; 0.79]	
Ohno et al. (2017)	25	39	13.6%	0.64 [0.47; 0.79]	
Cakmak et al. (2016)	18	19	15.2%	0.95 [0.74; 1.00]	
Concatto et al. (2015)	29	31	15.6%	0.94 [0.79; 0.99]	
Das et al. (2015)	16	20	12.8%	0.80 [0.56; 0.94]	
Koyama et al. (2015)	3	9	8.6%	0.33 [0.07; 0.70]	
Total (95% CI)	**123**	**165**	**100.0%**	**0.75 [0.62; 0.88]**	

Heterogeneity: $Tau^2 = 0.0262$; $Chi^2 = 33.59$, df = 7 (P < 0.01); $I^2 = 79\%$

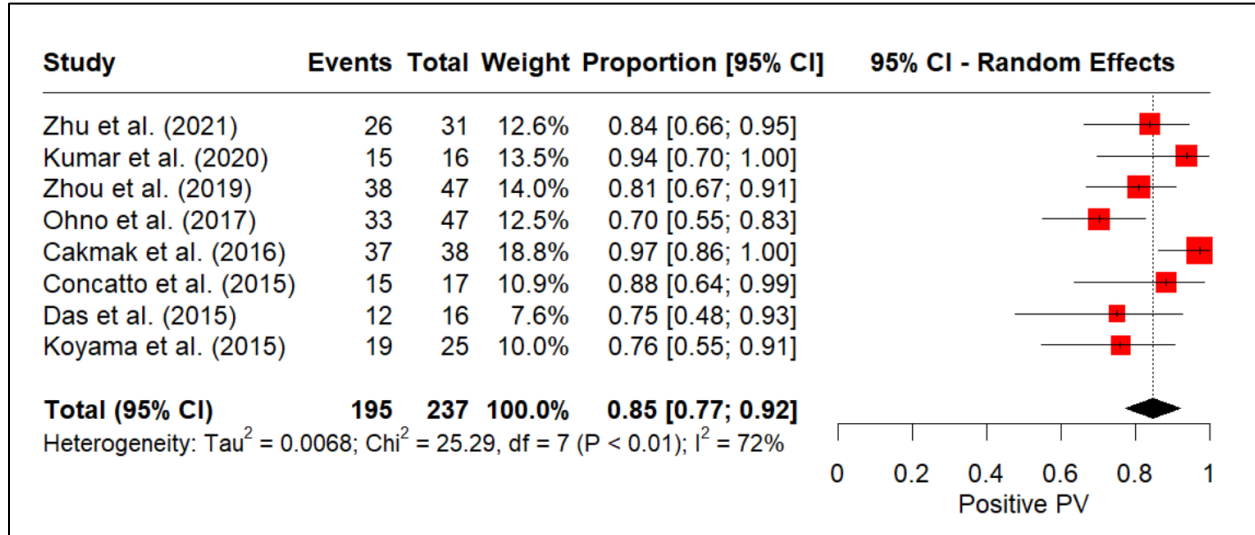*Events = TN, Total = TN + FP*

Figure 2. Random Forest Plot of Reported and Pooled Specificities

Random forest plots shows that the calculated pooled specificity is 0.75. This shows that in summary, the apparent diffusion coefficient (ADC) values derived by diffusion-weighted MRI correctly identify benign lung lesions using surgical histopathology or biopsy results 75% of the time. Consequently, 25% of the time, ADC values will identify true benign lung lesions as malignant.

In synthesizing the results, the weight given to studies were fairly distributed – with weights mostly around 10-15% each. This implies that no study extremely influenced the pooled value than the others.

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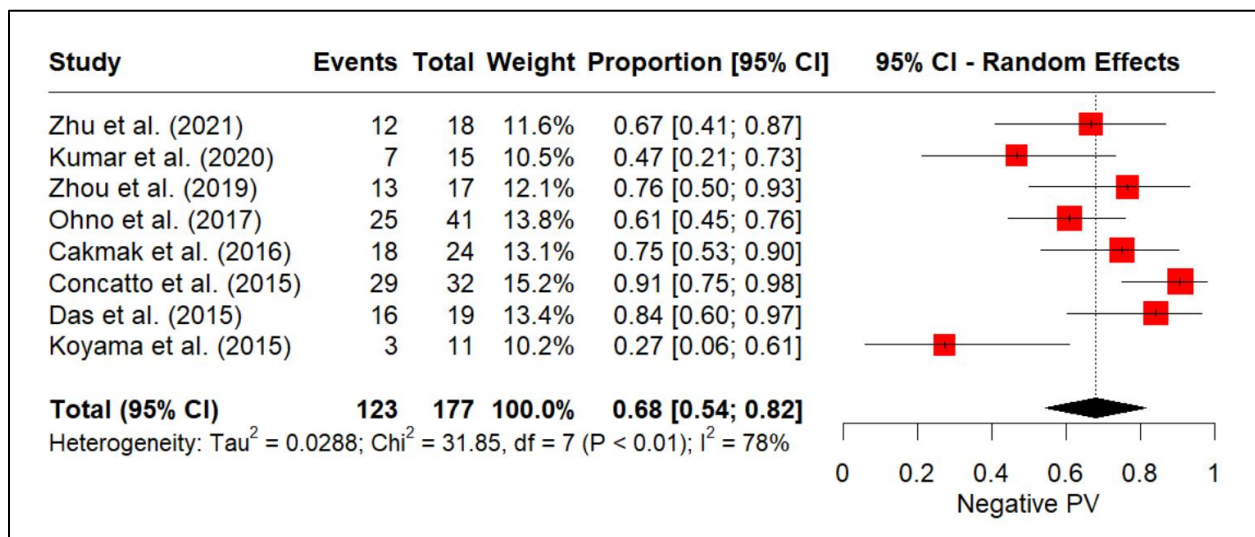

Events = TP, Total = TP + FP

Figure 3. Random Forest Plot of Reported and Pooled Positive Predictive Values (PPV)

Random forest plots shows that the calculated pooled positive predictive value (PPV) is 0.85. Therefore, the summary results of eight (8) studies indicate that about 85% of identified malignant lung lesions using ADC values are indeed malignant.

In synthesizing the results, the weight given to studies were fairly distributed – with weights mostly around 10-15% each. This implies that no study extremely influenced the pooled value than the others.
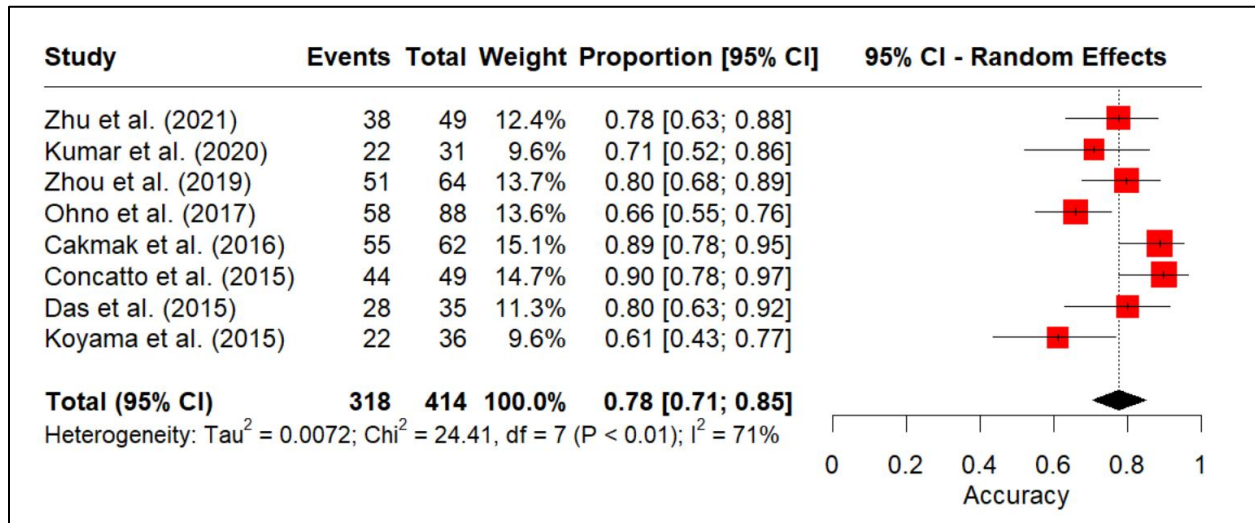

Events = TN, Total = TN + FN

Figure 4. Random Forest Plot of Reported and Pooled Negative Predictive Values (NPV)

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Random forest plots shows that the calculated pooled negative predictive value (NPV) is 0.68. Therefore, the summary results of eight (8) studies indicate that about 68% of identified benign lung lesions using ADC values are indeed benign.

In synthesizing the results, the weight given to studies were fairly distributed – with weights mostly around 10-15% each. This implies that no study extremely influenced the pooled value than the others.

Study	Events	Total	Weight	Proportion [95% CI]	95% CI - Random Effects
Zhu et al. (2021)	38	49	12.4%	0.78 [0.63; 0.88]	
Kumar et al. (2020)	22	31	9.6%	0.71 [0.52; 0.86]	
Zhou et al. (2019)	51	64	13.7%	0.80 [0.68; 0.89]	
Ohno et al. (2017)	58	88	13.6%	0.66 [0.55; 0.76]	
Cakmak et al. (2016)	55	62	15.1%	0.89 [0.78; 0.95]	
Concatto et al. (2015)	44	49	14.7%	0.90 [0.78; 0.97]	
Das et al. (2015)	28	35	11.3%	0.80 [0.63; 0.92]	
Koyama et al. (2015)	22	36	9.6%	0.61 [0.43; 0.77]	
Total (95% CI)	**318**	**414**	**100.0%**	**0.78 [0.71; 0.85]**	

Heterogeneity: $Tau^2 = 0.0072$; $Chi^2 = 24.41$, df = 7 (P < 0.01); $I^2 = 71\%$

Events = TP + TN, Total = TP + TN + FP + FN

Figure 5. Random Forest Plot of Reported and Pooled Accuracy

Random forest plots shows that the calculated accuracy is 0.78. This is a high value which indicates that generally, ADC values are highly accurate in identifying true malignant and benign lung lesions.

In synthesizing the results, the weight given to studies were fairly distributed – with weights mostly around 10-15% each. This implies that no study extremely influenced the pooled value than the others.

General Insights:

- Since cancer treatments are mostly invasive and expensive, we want to minimize false positives and improve specificity. The results of this meta-analysis shows that the use of ADC values to differentiate malignant and benign lung lesions suggest promising results in terms of specificity. However, setting a consistent threshold value should be investigated more.

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