The Prevalence of Toxocariasis and Diagnostic Value of Serologic Tests in Asymptomatic Korean Adults

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Purpose: Toxocariasis is the most common cause of peripheral blood eosinophilia in Korea and produces eosinophilic infiltration in various organs, including the lung. However, the prevalence of toxocariasis in the general population is rarely reported. **Methods:** We investigated the seroprevalence of *Toxocara* larval antibody among asymptomatic people who attended Samsung Medical Center for a health checkup, including low-dose chest computed tomography (CT) between March 2012 and December 2013. A total of 633 people (400 men and 233 women) were prospectively recruited. **Results:** The *Toxocara*-seropositive rate was 51.2% using the current cutoff value based on *Toxocara* enzyme-linked immunosorbent assay (ELISA) (67.0% for men and 24.0% for women). In the multivariate-adjusted model, age (odds ratio [OR], 1.08; 95% confidence intervals [CI], 1.04-1.11), male sex (OR, 3.47; 95% CI, 2.26-5.33), rural residence (OR, 1.55; 95% CI, 1.05-2.30), and history of raw liver intake (OR, 8.52; 95% CI, 3.61-20.11) were significantly associated with *Toxocara* seropositivity. When subjects were divided into 3 groups using cutoff values base on weak positive and strong positive control optical densities (ODs), the ORs for peripheral blood eosinophilia and serum hyperIgEaemia were 0.31 (95% CI, 0.02-2.89) in the weakpositive group and 36.64 (95% CI, 11.73-111.42) in the strong positive group compared to the seronegative group. Similarly, ORs for the solid nodule with surrounding halo were 2.54 (95% CI, 0.60-10.84) in the weak positive group and 15.08 (95 CI 4.09-55.56) in the strong positive group compared to the seronegative group. **Conclusions:** The study indicated that the *Toxocara*-seropositive rate obtained by using the current cutoff value based on ELISA was high in the asymptomatic population in Korea. The results of this study suggest that active toxocariasis may be more frequently seen in the *Toxocara*-strong positive group than in the *Toxocara*-weak positive group.

Key Words: *Toxocara* canis; toxocariasis; prevalence; diagnosis.

INTRODUCTION

Toxocara canis (*T. canis*) is a common helminth parasite of dogs.[1] Kang *et al.*[2] reported that the overall infection rate of intestinal parasites was 35.0% in all dogs, while those of *T. canis* were 1.6% in indoor dogs and 10.6% in outdoor dogs in South Korea. *T. canis* can also infect other animals, including mice, chickens, pigs, and cows through ingestion of embryonated eggs of *T. canis* in soil.[3-8] Hatched larvae can penetrate the intestinal mucosa and travel through the blood stream into the liver, lungs, and other organs by visceral migration.[9] Although the life cycle of the parasite is completed only in dogs, the larvae of T. canis may be encapsulated and remain alive in a dormant form in the tissues of other animals, including humans.[9,10] Rashman *et al.*,[8] reported that the overall infection rate of intestinal parasites was 78.0% in cattle, while the infection rate of *T. canis* was

3.0% in cattle of Bangladesh. Some Korean researchers reported high infection rates of intestinal parasites in pigs and cattle,[2,11-14] but there has been no report on *T. canis* infection in pigs or cattle of South Korea.

Toxocariasis is the clinical term applied to human infections with *T. canis*,[15] which are usually caused by ingesting embryonated eggs from soil/water or by eating raw animal tissues containing infective larvae.[9,16] Clinical features of toxocariasis can

be classified as visceral larva migrans or ocular larva migrans according to affected organs.[1] Toxocariasis is also known to be the most common cause of peripheral blood eosinophilia and eosinophilic infiltration in various organs in Korea.[17-19] Our previous study showed that the prevalence of toxocariasis was high in patients with eosinophilia of unknown origin.[17] Toxocariasis may present with cough, dyspnea, chest discomfort resembling asthma, itchy sensation of skin, or gastrointestinal discomfort.[17] The symptoms can often be subtle or absent. However, toxocariasis resulting from latent or long-term exposure to infective larvae may also be accompanied by central nervous system (CNS) involvement, such as seizure, myelitis, and encephalopathy.[20,21]

The prevalence and clinical characteristics of toxocariasis in asymptomatic subjects have rarely been reported in Korea. Most of the previous studies have included a relatively small number of participants without radiologic evaluation.[22-24] The clinical implications and significance of the current immunologic diagnosis of toxocariasis have not been fully evaluated. Thus, the objective of this study was to evaluate *Toxocara*-seropositive rates in asymptomatic Korean adults and clinical implications of the current diagnosis of toxocariasis.

MATERIALS AND METHODS

Participants

The study population consisted of subjects who underwent low-dose chest computed tomography (CT) as part of a comprehensive health checkup examination between March 2012 and December 2013. We prospectively collected potential participants who were voluntarily taking screening examinations including blood tests, stool examinations, abdominal sonography, and low-dose chest CT at Center for Health Promotion of Samsung Medical Center in Seoul, Korea. All who consented to the study were enrolled in the study. Physician interviewers requested voluntary participation in this study, and written, fully informed consent was obtained from each participant before the study began. The study protocol was approved by the Institutional Review Board of Samsung Medical Center in Seoul, Korea.

Methods

During face-to-face interviews, we obtained information on the clinical data of the participants, including age, gender, residence in the urban area (7 main cities: Seoul, Incheon, Daejeon, Daegu, Busan, Ulsan, and Gwangju), and history of raw food intake, including raw liver and raw meat. The amount of raw liver intake in the past year was graded as none, small (less than 10 mouthfuls), moderate (less than 20 mouthfuls), or large (more than 20 mouthfuls). Radiologic findings suggesting involvement of organs, including the lungs and liver (by low-dose chest CT and hepatic ultrasonography), and laboratory find-

ings suggesting parasitic infestation (stool examinations, peripheral blood eosinophil counts, *Toxocara*-specific IgG levels, and serum IgE levels) were reviewed by the trained staff. Eosinophilia was defined as more than 500 cells/µL or 10% of leukocytes in peripheral blood. Serum samples for total IgE and serologic measurements were collected and stored at -20°C until needed. The serum total IgE level was measured using the ImmunoCAP250 (Pharmacia and Upjohn Diagnostics AB, Uppsala, Sweden). The upper normal limit of serum total IgE was 200 U/mL.

A serologic diagnosis of *Toxocara* infection was established by measuring specific IgG antibody to *T. canis* with a *Toxocara* ELISA kit (Bordier Affinity Products, Crissier, Switzerland) as previously described.[17] The result was considered positive when the absorbance of the sample was higher than the absorbance of the weak positive control. A standardized *Toxocara* value was presented as a *Toxocara* ratio, which was defined as the participant's *Toxocara* IgG optical density (OD) over a weak positive control OD. *Toxocara* seronegativity was defined when a participant's *Toxocara* OD was less than that of a weak positive control OD. Participants were divided into 3 groups according to *Toxocara* grade: those who had *Toxocara* OD less than that of the weak positive control OD (negative group), those who had *Toxocara* OD between the weak and strong positive control ODs (weak positive group), and those who had *Toxocara* OD greater than the strong positive control OD (strong positive group).

Statistical analysis

Categorical variables are summarized as percentages with 95% confidence intervals (CI). Continuous variables are summarized as medians with interquartile range or 95% CI unless indicated otherwise. We performed univariate and multivariate regression analyses to evaluate variable factors associated with *Toxocara* seropositivity or *Toxocara* grade. We initially searched for individual parameters-age, sex, residence, history of raw food intake in the past year, history of raw liver intake, history of raw meat intake, amount of raw liver intake, history of pet raising, serum hyperIgEaemia, peripheral blood eosinophilia, any lung nodule including solid nodule, ground-glass opacity, nodule with a surrounding halo, and consolidation, on chest CT, and hypoechoic liver involvement suggesting parasitic infestation.[25] We calculated a crude model and models adjusted for age, sex, and all variables, which were associated with *Toxocara* seropositivity or *Toxocara* grade with P values <0.10 in univariate analysis. Multicollinearity was tested using the variance inflation factor. There was a significant correlation between history of raw food intake and the amount of raw liver intake, so that the model was not adjusted for the amount of raw liver intake. The multinominal outcome for analysis was *Toxocara* grade; the negative group was the base reference category. Two-sided P values <0.05 were considered statistically significant. All data

was analyzed using Stata version 13.0 (StataCorp, College Station, USA).

RESULTS

During the study period, 633 (400 men and 233 women) of the 697 people were voluntarily recruited. Their median age (interquartile range) was 51 (49-58) years. Table 1 presents the demographic characteristics of the study population, and Table 2 presents differences in variables according to *Toxocara* seropositivity and *Toxocara* grade. Among the 633 participants, 324 (51.2%) had positive results in the *Toxocara* ELISA (67.0% for men and 24.0% for women). The *Toxocara*-seropositive rates were 8.3%, 38.9%, 55.8%, and 58.7% of age groups of <40, 40-49, 50-59, and ≥60 years, respectively. The *Toxocara*-seroposi-

tive rates in urban and rural areas were 45.9% and 56.8%, respectively. By the residence area, the *Toxocara*-seropositive rates were 44.4% (115 out of 259) in Seoul; 45.6% (41 out of 90) in Daegu, Busan, Ulsan, and Gyeongsang-do; 54.2% (109 out of 201) in Incheon and Gyeonggi-do; 67.7% (21 out or 31) in Gwangju and Jeolla-do; 69.6% (32 out of 46) in Daejeon and Chungcheong-do; and 75% (3 out of 4) in Gangwon-do.

The prevalence of *Toxocara* seropositivity was significantly higher in participants with history of raw liver intake and those with a large amount of raw liver intake. Compared to participants without *Toxocara* seropositivity, those with *Toxocara* seropositivity had higher prevalences of blood eosinophilia, serum hyperIgEaemia, the solid lung nodule with surrounding halo, and the liver lesion. The recent history of raw food intake, amount of raw liver intake, peripheral blood eosinophilia, and

Table 1. Demographic characteristics of the study population (N=633)

Characteristic	Total N=633 n (%)	*Toxocara* Grade			*P* value
		Negative less than weak-positive control OD N=309 n (%)	Weak positive between weak & strong-positive control OD N=145 n (%)	Strong positive greater than the strong-positive control OD N=179 n (%)	
Age (year)	53 (49-58)	51 (48-57)	54 (50-60)	55 (51-59)	<0.001
Sex					
Female	233 (36.8)	177 (76.0)	37 (15.9)	19 (8.1)	<0.001
Male	400 (63.2)	132 (33.0)	108 (27.0)	160 (40.0)	
Residency					
Urban*	327 (51.7)	177 (54.1)	73 (22.3)	77 (23.6)	0.009
Rural	306 (48.3)	132 (43.2)	72 (23.5)	102 (33.3)	
Pet raising					
No	438 (69.2)	227 (51.8)	105 (24.0)	106 (24.2)	0.580
Yes	154 (24.3)	73 (47.4)	38 (24.7)	43 (27.9)	
Unknown	41 (6.5)	9 (22.0)	2 (4.9)	30 (73.2)	
Recent history of raw food intake					
No	251 (39.7)	193 (76.9)	42 (16.7)	16 (6.4)	<0.001
Yes	382 (60.3)	116 (30.7)	101 (26.7)	161 (42.6)	
Meat	99 (15.6)	58 (58.6)	22 (22.2)	19 (19.2)	
Liver	36 (5.7)	9 (25.0)	11 (30.6)	16 (44.4)	
Liver & meat	247 (39.0)	49 (20.2)	70 (28.0)	128 (51.8)	
Amount of raw liver intake					
No	350 (55.3)	251 (71.7)	64 (18.3)	35 (10.0)	<0.001
Small	137 (21.6)	43 (31.4)	61 (32.8)	60 (35.8)	
Moderate	77 (12.2)	8 (10.4)	23 (29.9)	46 (59.7)	
Large	53 (8.4)	5 (9.4)	11 (20.8)	37 (69.8)	
Unknown	16 (2.5)	2 (12.5)	2 (12.5)	12 (75.0)	

Variables are expressed as number (percentages), or median (interquartile range).
*Seoul, Incheon, Daejeon, Daegu, Busan, Ulsan, and Gwangju.
A serologic diagnosis of *Toxocara* infection was done by measuring the specific IgG antibody to *T. canis* with a *Toxocara* ELISA kit (Bordier Affinity Products, Crissier, Switzerland). Participants were divided into 3 groups according to *Toxocara* grade: those who had *Toxocara* OD less than that of the weak positive control OD (negative group), those who had *Toxocara* OD between the weak and strong positive control ODs (weak positive group), and those who had *Toxocara* OD greater than the strong positive control OD (strong positive group).

Table 2. Clinical characteristics of the study population (N=633)

Characteristic	Total N=633 n (%)	*Toxocara* Grade			P value
		Negative less than weak-positive control OD N=309 n (%)	Weak postive between weak & strong-positive control OD N=145 n (%)	Strong positive greater than the strong-positive control OD N=179 n (%)	
Peripheral blood eosinophil, ×10³/μL	152 (84-325)	128 (71-198)	135 (84-234)	401 (153-785)	0.020
Peripheral blood eosinophilia (≥500×10³/μL or 10%)					<0.001
No	518 (81.8)	281 (54.3)	139 (26.8)	98 (18.9)	
Yes	115 (18.2)	28 (24.4)	6 (5.2)	81 (70.4)	
Serum IgE (median, range), U/mL	56 (18-213)	28 (11-71)	60 (22-463)	295 (107-682)	<0.001
Serum HyperIgEaemia (IgE≥ 200 U/mL)					
No	465 (73.5)	284 (61.1)	116 (24.9)	65 (14.0)	
Yes	168 (26.5)	25 (14.9)	29 (17.3)	114 (67.8)	
Blood Laboratory findings					
Eosinophilia (-) & HyperIgEaemia (-)	426 (67.3)	262 (61.5)	111 (26.1)	53 (12.4)	<0.001
Eosinophilia (+) & HyperIgEaemia (-)	39 (6.2)	22 (56.4)	5 (12.8)	12 (30.8)	
Eosinophilia (-) & HyperIgEaemia (+)	92 (14.5)	19 (20.7)	28 (30.4)	45 (48.9)	
Eosinophilia (+) & HyperIgEaemia (+)	76 (12.0)	6 (7.9)	1 (1.2)	69 (90.8)	
Lung solid nodule					
No	556 (87.8)	282 (50.7)	135 (24.3)	139 (25.0)	<0.001
Yes	77 (12.2)	27 (35.1)	10 (13.0)	40 (51.9)	
Lung solid nodule with surrounding halo					
No	590 (93.2)	305 (51.7)	140 (23.7)	145 (24.6)	<0.001
Yes	43 (6.8)	4 (9.3)	5 (11.6)	34 (79.1)	
Lung ground-glass opacity					
No	590 (93.2)	291 (49.3)	136 (23.1)	163 (27.6)	0.399
Yes	43 (6.8)	18 (41.9)	9 (20.9)	16 (37.2)	
Lung consolidation					
No	613 (96.8)	303 (49.4)	142 (23.2)	168 (27.4)	0.026
Yes	20 (3.2)	6 (30.0)	3 (15.0)	33 (55.0)	
Liver lesion					
No	622 (98.3)	306 (49.2)	146 (23.5)	170 (27.3)	0.002
Yes	11 (1.7)	2 (18.2)	0 (0.0)	9 (81.8)	

Variables are expressed as number (percentages), or median (interquartile range). *Toxocara* grade as in Table 1.
OD, optical density.

serum HyperIgEaemia were positively associated with *Toxocara* grade (Fig. 1). The frequencies of factors suggesting current toxocariasis, including peripheral blood eosinophilia, serum hyperIgEaemia, and lung/liver involvement, became higher as *Toxocara* grade increased from weak positivity to strong positivity (Table 2).

The median standardized *Toxocara* values according to the variables are shown in Fig. 2. The median standardized *Toxocara* values were higher in participants with history of raw liver intake, those with a large amount of raw liver intake, and those with peripheral blood eosinophilia and serum hyperIgEaemia.

Table 3A shows the results of univariate analysis using logistic regression. Pet raising was not related to *Toxocara* seropositivity (OR, 1.19; 95% CI, 0.83-1.72; *P*=0.345). In the multivariate-adjusted model, old age (OR, 1.08; 95% CI, 1.04-1.11; *P*<0.001), male sex (OR, 3.47; 95% CI, 2.26-5.33; *P*<0.001), and rural residence (OR, 1.55; 95% CI, 1.05-2.30; *P*=0.027) were significantly associated with *Toxocara* seropositivity (Table 3B). OR for *Toxocara* seropositivity in participants with history of both raw liver and meat intake was 8.88 (95% CI, 5.53-14.25; *P*<0.001) compared to those without raw food intake. OR for *Toxocara* seropositivity in participants with eosinophilia and hyperIgEaemia
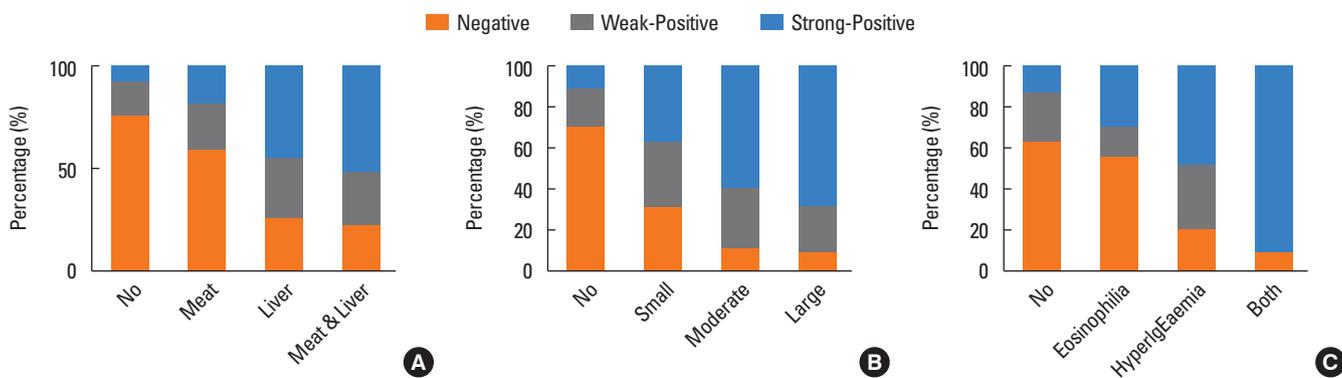
Fig. 1. Proportion of _Toxocara_ grade according to variables in the study population. (A) The proportion of _Toxocara_ grade according to history of raw-food intake. (B) The proportion of _Toxocara_ grade according to the amount of raw liver intake. (C) The proportion of _Toxocara_ grade according to peripheral blood eosinophilia and serum hyperIgEaemia. Paticipants were divided into 3 groups according to _Toxocara_ grade: those with _Toxocara_ optical density (OD) less than a weak-positive control OD (negative group), those with _Toxocara_ OD between weak positive and strong positive control ODs (weak positive group), and those with _Toxocara_ OD greater than the strong-positive control OD (strong positive group).
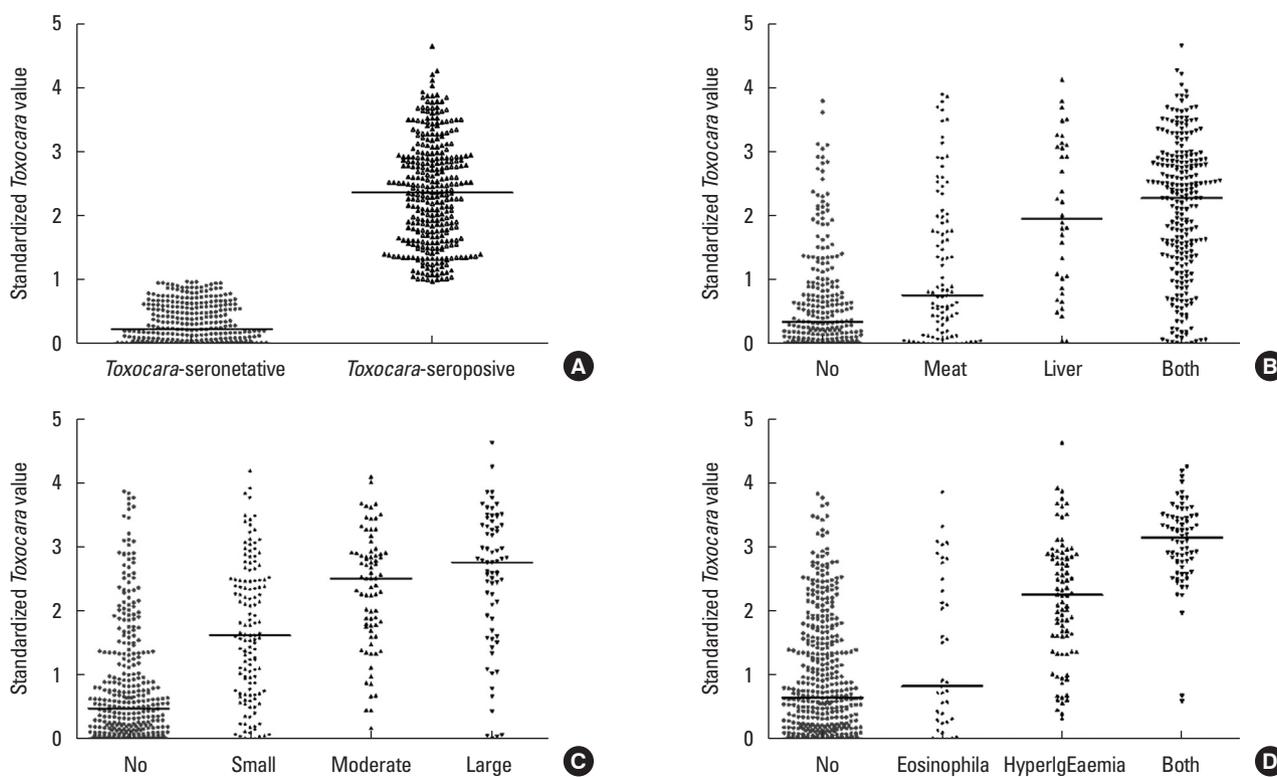

Fig. 2. Standardized _Toxocara_ values according to variables in the study population. (A) The median standardized _Toxocara_ values (interquartile range) were 0.26 (0.06-0.61) in the _Toxocara_-seronegative group and 2.38 (1.66-2.93) in the _Toxocara_-seropositive group. (B) The median standardized _Toxocara_ values were 0.36 (0.07-0.95) in participants without history of raw food intake, 0.78 (0.15-1.93) in those with history of raw meat intake, 1.96 (0.96-3.10) in those with history of raw liver intake, and 2.29 (1.33-2.88) in those with history of both raw liver and raw meat intake. (C) The median standardized _Toxocara_ values were 0.49 (0.09-1.27) in participants with no raw liver intake, 1.64 (0.77-2.51) in those with a small amount of raw liver intake, 2.53 (1.80-2.93) in those with a moderate amount of raw liver intake, and 2.62 (1.71-3.36) in those with a large amount of raw liver intake, (D) The median standardized _Toxocara_ values were 0.67 (0.16-1.57) in participants with normal eosinophil count and IgE level, 0.85 (0.28-2.53) in those with peripheral blood eosinophilia, 2.14 (1.36-2.86) in those with serum hyperIgEaemia, and 3.12 (2.63-3.28) in those with both peripheral blood eosinophilia and serum hyperIgEaemia.

was 9.64 (95% CI, 3.54-26.24; _P_<0.001) compared to those with normal eosinophil count and IgE level. OR for _Toxocara_ seropositivity was 6.97 (95% CI, 2.12-22.90; _P_<0.001) in participants

with the solid nodule with surrounding halo on low-dose chest CT compared to those without the lesion.

Univariate analysis using multinominal logistic regression

Table 3A. Crude prevalence ratios of *Toxocara* seropositivity according to associated factors

Characteristic	Crude OR		
	OR	95% CI	P value
Age (year)	1.06	1.04-1.09	<0.001
Male sex	6.42	4.45-9.24	<0.001
Residence in rural area	1.56	1.14-2.13	0.006
Pet raising	1.19	0.83-1.72	0.345
Recent history of raw food intake			
Meat	2.35	1.43-3.86	0.001
Liver	9.98	4.44-22.43	<0.001
Liver & meat	13.17	8.58-20.24	<0.001
Amount of raw liver intake			
Small	5.54	3.61-83.51	<0.001
Moderate	21.87	10.14-47.14	<0.001
Large	24.34	9.14-62.93	<0.001
Peripheral blood eosinophilia	3.68	2.33-5.83	<0.001
Serum HyperIgEaemia	8.99	5.65-14.31	<0.001
Blood Laboratory findings			
Eosinophilia (+) & HyperIgEaemia (-)	1.23	0.64-2.39	0.053
Eosinophilia (-) & HyperIgEaemia (+)	6.14	3.57-10.55	<0.001
Eosinophilia (+) & HyperIgEaemia (+)	18.64	7.92-43.88	<0.001
Lung solid nodule	1.91	1.16-3.13	0.011
Lung solid nodule with surrounding halo	10.43	3.68-29.57	<0.001
Lung ground-glass opacity	1.35	0.72-2.53	0.343
Lung consolidation	2.28	0.87-6.01	0.096
Liver lesion	4.39	0.94-20.46	0.060

OR, odds ratio; CI, confidence interval.

Table 3B. Adjusted prevalence ratios *Toxocara* seropositivity according to associated factors

Characteristic	Crude OR		
	OR	95% CI	P value
Age (year)	1.08	1.04-1.11	<0.001
Male sex	3.47	2.26-5.33	<0.001
Residence in rural area	1.55	1.05-2.30	0.027
Recent history of raw food intake			
Meat	1.96	1.14-3.35	0.014
Liver	8.52	3.61-20.11	<0.001
Liver & meat	8.88	5.53-14.25	<0.001
Blood Laboratory findings*			
Eosinophilia (+) & HyperIgEaemia (-)	1.12	0.50-2.49	0.790
Eosinophilia (-) & HyperIgEaemia (+)	4.22	2.27-7.87	<0.001
Eosinophilia (+) & HyperIgEaemia (+)	9.64	3.54-26.24	<0.001
Lung solid nodule*	1.65	0.57-1.98	0.843
Lung solid nodule with surrounding halo*	6.97	2.12-22.90	0.001
Lung consolidation*	2.61	0.79-8.66	0.116
Liver lesion*	2.74	0.37-20.00	0.321

*The model was adjusted for age, sex, residence, and history of raw food intake.
OR, odds ratio; CI, confidence interval.

demonstrated that the presence of eosinophilia and hyperIgEaemia, the solid lung nodule with consolidation, the solid lung nodule with surrounding halo, and the liver lesion were significantly associated with high *Toxocara* grade (Table 4A). Adjustment for age, sex, residence, and recent history of raw food intake eliminated the association of the solid lung nodule and the liver lesion with *Toxocara* grade (Table 4B).

DISCUSSION

Although toxocariasis occurs worldwide, the prevalence of *Toxocara* seropositivity in the general population varies from country to country.[26] In Western countries, toxocariasis is generally regarded as a disease of children who come in contact with soil contaminated with *Toxocara* eggs.[27] However, in Eastern countries, recent studies suggested that toxocariasis may be a food-mediated infectious disease that affects adults who consume raw food.[16,17,22]

From this study in asymptomatic Korean adults, we identified 3 major findings. First, the prevalence of *Toxocara* seropositivity was high according to the current cutoff value based on *Toxocara* ELISA. Second, the history of raw liver intake significantly increased the risk of toxocariasis in a dose-dependent manner. Third, findings suggesting active toxocariasis were more frequently seen in the *Toxocara*-strong positive group categorized by using the strong positive cutoff value compared to the current cutoff value.

Toxocara-seropositive rates were 51.2% in this study and 57.3% (86 of 150 healthy people) in our previous study.[16] Multivariate analysis indicated that old age, male sex, rural residence, and presence of a history of raw liver intake were significantly associated with *Toxocara* seropositivity. The *Toxocara*-seropositive rate increased with age. As age increases, people may have more chances to ingest raw food and to have past, current, and recurrent toxocariasis. There was a male preponderance. The reason for this may be the cultural background in Korea where men ingest more raw food than women. The history of raw liver intake was reported to be 59.9% in males vs 17.7% in females. Therefore, this study suggests that old males who live in rural areas with frequent raw-liver eating habits are at higher risk of toxocariasis.

We observed that *Toxocara*-seroprevalence rates varied from 44.4% to 75.0% according to residential areas. Several researchers reported that *Toxocara*-seroprevalence rates in the general population in Korea vary from 5.0% to 11.3% as asassessed by using a self-made ELISA kit.[23,28,29] This discrepancy may have resulted from differences in diagnostic ELISA kits with different

Table 4A. Crude odds ratios for *Toxocara* grade according to variables suggesting active infection

	Toxocara Grade	
	Weak positive between weak & strong positive control OD	Strong positive greater than the strong positive control OD
Blood Laboratory findings (vs. No)		
Eosinophilia (+) & HyperIgEaemia (-)	0.54 (0.20-1.45)	2.70 (1.26-5.78)*
Eosinophilia (-) & HyperIgEaemia (+)	3.48 (1.86-6.49) ‡	11.71 (6.35-21.59) ‡
Eosinophilia (+) & HyperIgEaemia (+)	0.39 (0.05-3.31)	56.85 (23.46-137.73) ‡
Lung solid nodule	0.77 (0.36-1.64)	3.01 (1.77-5.10) ‡
Lung solid nodule with surrounding halo	2.72 (0.72-10.30)	17.88 (6.23-51.33) ‡
Lung ground-glass opacity	1.07 (0.47-2.44)	1.59 (0.79-3.20)
Lung consolidation	1.07 (0.26-4.33)	3.31 (1.20-9.10)*
Liver lesion		8.15 (1.74-38.17)†

Values are odds ratio (95% confidence interval). Estimated from multinominal logistic regression model that used *Toxocara* grade as outcomes categorized as negative, weak-positive, and strong-positive. Reference category is the negative group. *$P<0.05$, †$P<0.01$, ‡$P<0.001$ (two-tailed tests).
OD, optical density.

Table 4B. Adjusted odds ratios for *Toxocara* grade according to variables suggesting active infection

	Toxocara Grade	
	Weak positive between weak & strong positive control OD	Strong positive greater than the strong positive control OD
Blood Lab findings (vs. No)§		
Eosinophilia (+) & HyperIgEaemia (-)	0.53 (0.18-1.57)	2.76 (1.06-7.18)*
Eosinophilia (-) & HyperIgEaemia (+)	2.75 (1.38-5.46) †	8.23 (4.02-16.85) ‡
Eosinophilia (+) & HyperIgEaemia (+)	0.31 (0.02-2.89)	36.64 (11.73-111.42) ‡
Lung solid nodule§	0.544 (0.24-1.24)	1.72 (0.86-3.45)
Lung solid nodule with surrounding halo§	2.54 (0.60-10.84)	15.08 (4.09-55.56) ‡
Lung consolidation§	1.40 (0.31-6.34)	4.97 (1.28-19.30)*
Liver lesion§		5.82 (0.68-19.80)

Values are odds ratio (95% confidence interval). Estimated from multinominal logistic regression models that used *Toxocara* grade as outcomes categorized as negative, weak positive, and strong positive. §The model was adjusted for age, sex, residence, and history of raw food intake. Reference category is the negative group.
*$P<0.05$, †$P<0.01$, ‡$P<0.001$ (two-tailed tests).
OD, optical density.

sensitivity and from differences in study populations. Because the definite tissue confirmation of toxocariasis is extremely difficult, toxocariasis is usually diagnosed by measuring IgG antibody to *Toxocara*, although the currently used cutoff value cannot clearly discriminate the current active infection from remote or past infections.[1,15,30] We used commercial ELISA kits from Bordier with a sensitivity of 86% and a specificity of 91%.[17] The participants in our study are different from those of other studies in that they visited our hospital voluntarily with main concern about good health. They are usually in a high socioeconomic status that offers more chances to encounter expensive raw food. Cross-reactions with other helminth antigens may be another explanation for the higher prevalence in our study.[30] Further studies are necessary to accumulate more evidence to set the cutoff value for *Toxocara* infection based on ELISA.

Clinically, increased blood eosinophil counts and elevated se-

rum IgE levels, as well as the solid lung nodule with halo on chest CT, suggest active *Toxocara* infection. These findings were more frequently seen in participants with a strong-positive titer of antibody to *Toxocara*, implying the association of the activity of *Toxocara* infection with the titer of IgG antibody to *Toxocara*. The association between liver lesions and *Toxocara* seropositivity/*Toxocara* grade was no longer statistically significant after multivariate adjustment. This may be due to the small number of liver lesions detected in this study. Because *Toxocara* larvae could migrate to the liver in the early stage of infection, most larvae could be trapped and destroyed within the liver, and toxocariasis of the liver may induce few symptoms. Because our study was conducted on asymptomatic subjects with varying time intervals from raw food intake, liver lesions could have been overlooked. According to animal studies, larvae can reach the liver in 2 days, the lung in 3 days, and the CNS in 7 days after

oral ingestion.[31] In clinical settings, it is not possible to assess exact time for organ involvement after oral ingestion in human toxocariasis because we cannot determine the exact date of raw food ingestion in individual participants and because serologic tests are performed at different time points after ingestion.

The major strengths of our study include detailed information on many of potential confounders and the use of a relatively large sample size with all participants undergoing general health checkups, including low-dose chest CT. However, our study has several limitations. First, our study participants were recruited from a health promotion center of a tertiary care hospital. There may have been selection bias due to inclusion of relatively wealthy participants with main concern about good health, and thus our participants may not represent the general Korean population. Second, recall biases could have been present in the recall data regarding the participants' history of raw food intake. Third, diagnoses of toxocariasis were made by detecting antibody (sensitivity 86%, specificity 91%) without pathological verification because tissue confirmation is not usually possible in clinical settings. In this study, all individuals underwent stool examination with negative results. However, common parasites other than *Toxocara* were not assessed by using ELISA, although cross-reactions among helminthic infections may be negligible.[32] Therefore, false positivity in ELISA could not be avoided. Moreover, since IgG antibody to *Toxocara* remains elevated for several months to years following single or repeated infections,[33,34] the current cutoff value for *Toxocara* seropositivity may not have indicated active toxocariasis. Finally, this is a cross-sectional study, so it was not possible to examine the relationship between *Toxocara* seropositivity and associated factors. Prospective studies should be conducted to validate our results.

In summary, the prevalence of toxocariasis in the asymptomatic Korean population was high as assessed with the current cutoff value. Factors associated with *Toxocara* seropositivity were raw liver intake, serum hyperIgEaemia without peripheral blood eosinophilia, and the solid lung nodule with surrounding halo. When our participants were divided into 3 groups according to the cutoff values based on weak-positive and strong-positive control ODs, the prevalence for peripheral blood eosinophilia with serum hyperIgEaemia and the solid lung nodule with surrounding halo became higher as *Toxocara* grade increased.

There remain questions as to how active *Toxocara* infection should be defined and how it can be distinguished from remote or past infections. To estimate the level of exposure and detect early infection, we may use low cutoff values to capture any exposure, even if this exposure does not lead to active toxocariasis. On the other hand, it may be better by using high cutoff values that will be more correlated with higher likelihoods of active toxocariasis. Therefore, further studies are needed to determine a useful cutoff value for current toxocariasis based on *Toxocara* ELISA.

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