Glycemic Control, Coping, and Internalizing and Externalizing Symptoms in Adolescents With Type 1 Diabetes

A cross-lagged longitudinal approach

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OBJECTIVE — This study examines how active coping and withdrawal, psychological (internalizing and externalizing) symptoms, and glycemic control (A1C values) influence each other across time in adolescents with type 1 diabetes.

RESEARCH DESIGN AND METHODS — One hundred and nine adolescents participated in a four-wave longitudinal study spanning four years (mean age at Time 1 was 13.77). Patients were visited at home and completed questionnaires measuring coping and psychological symptoms. The treating physicians were contacted to obtain A1C values. Cross-lagged path analysis from a structural equation modeling approach was used for data analysis.

RESULTS — Clinically meaningful pathways between coping and glycemic control were found across time. Active coping prospectively predicted lower A1C levels, which, in turn, predicted active coping. Higher A1C levels and higher psychological symptoms consistently predicted avoidance coping across time. Finally, psychological symptomatology constituted an important link in the observed longitudinal chain of effects. More specifically, higher A1C values and symptomatology at Time 1 positively predicted withdrawal at Time 2, which, in turn, positively predicted symptomatology at Time 3. Next, symptomatology at Time 3 positively predicted higher A1C values at Time 4, thus coming full circle.

CONCLUSIONS — Coping with everyday stress, psychological symptoms, and glycemic control were interrelated across time. Evidence was obtained for reciprocal pathways and mutually reinforcing mechanisms, indicating the need to monitor coping strategies and psychological symptoms along with glycemic control in optimizing clinical care in adolescents with type 1 diabetes.

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A dolescence can be a challenging time when individuals have to deal with several developmental tasks such as growing independent from parents and developing mature peer relationships. Having type 1 diabetes imposes multiple additional demands on the adolescent, invading every aspect of his or her life. Diabetes management requires a great deal of self-discipline and is perceived as being highly stressful (1). Consequently, several studies suggest that adolescents with diabetes are at a greater risk than their healthy peers for developing psychological symptoms (such as internalizing and externalizing symptoms, which are both being assessed in this study) or even psychiatric disorders (e.g., depressive disorder) (2–4). However, other studies did not find increased levels of psychological symptoms in these adolescents (5,6), which could signal their increased competence in managing their illness and coping with age-specific developmental tasks. Psychological symptoms (such as internalizing or, more specifically, depressive symptoms) can negatively influence glycemic control through physiological channels and/or through behavioral pathways thereby reducing treatment adherence (4,7). In turn, such symptoms can also be a consequence of poorly controlled diabetes (e.g., due to repeated stressful episodes of severe diabetic ketoacidosis and diabetic microvascular complications such as retinopathy) (3,8–10). As such, the relationship between psychological symptoms and glycemic control is hypothesized to be a reciprocal one.

Several studies have shown that many adolescents have difficulty coping with various illness-specific and everyday stressors, show low adherence with their prescribed treatment, and/or poor glycemic control (11,12). Seiffge-Krenke et al. (13,14) distinguished between functional and dysfunctional coping. Functional coping refers to efforts to manage a problem by actively seeking support, taking concrete actions, or reflecting on possible solutions. Dysfunctional coping includes efforts to withdraw from or deny the existence of the stressor and to avoid seeking solutions and, as such, risk exacerbating the effects of stress (11). Adolescents using active coping skills were less likely to show a worsening in their glycemic control, implying that their coping competencies had a protective effect (15). The consistent use of withdrawal or avoidance coping has been linked to increases in psychological symptoms in community samples (16). In sum, adolescents with diabetes who use withdrawal coping may be at risk for psychological symptoms and poor glycemic control. Some have suggested that these relationships may be reciprocal (1).

The present study

Despite the burgeoning literature dealing with psychological functioning and dia-

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betes, neither adolescents' coping strategies nor their capacity to achieve adequate glycemic control have been addressed in a single longitudinal design. However, psychological symptoms, coping, and glycemic control are hypothesized to influence each other across time (17). As opposed to cross-sectional relations, which reveal whether two variables are simultaneously related, cross-lagged (longitudinal) relations reveal whether a certain variable is related to changes in another variable. For example, Helgeson et al. (18) found that, although depressive symptoms were not related to glycemic control at a concurrent level in their adolescent sample, depressive symptoms were found to predict decreases in glycemic control across time. Consequently, through the use of cross-lagged path analysis in a longitudinal sample of adolescents with diabetes, the present study examined how coping and psychological symptoms (both internalizing and externalizing) influenced glycemic control across time. We expected that active coping would be related to good glycemic control, whereas withdrawal coping and experiencing psychological symptoms would be related to poor glycemic control across time. Further, we hypothesized that reciprocal mechanisms set in motion a detrimental vicious circle in which withdrawal coping and increases in psychological symptoms could not only influence but also could be influenced by poor glycemic control (1).

As noted, the use of active coping was expected to break this chain of mechanisms by improving glycemic control or protecting against psychological symptoms. The present study also took into account possible sex differences as girls generally have higher A1C values due to pubertal acceleration and higher internalizing symptom scores (1,13,18).

RESEARCH DESIGN AND METHODS

Participants and procedure
Participants were from the German Longitudinal Study on Juvenile Diabetes (1), which received full Institutional Review Board approval from the University of Mainz, Mainz, Germany. All participants provided informed consent. A total of 109 patients with type 1 diabetes (47% girls and 9% of non-German—mainly Turkish, Italian, and Greek—descent) were recruited from 17 pediatric health care services offering outpatient care in two German cities (12% of the patients ini-

tially contacted declined to participate mainly due to language problems). The sample was found to be representative of German adolescents of the same age range on different demographic variables (1). The 109 patients participated in a four-wave longitudinal study spanning four years. Participants were visited at home by project team members and were asked to fill out questionnaires. Mean age at Time 1 was 13.77 (SD = 1.41; range 12–16 years with 71% of the sample being 12–14 years). As such, the majority of the participants were in their early adolescent years at Time 1 and in their middle to late adolescent years at Time 4. Further, with respect to paternal educational level, 19% of the patients had fathers who received education to the 10th grade level, 53% to 11th or 12th grade level, and 23% to the college level. Mean duration of diabetes at Time 1 was 4.95 years (SD = 3.48). Illness duration and age were unrelated to all study variables except for a positive association of illness duration with A1C values at Time 1 ($r = 0.22$; $P < 0.05$) and of age with psychological symptoms at Time 1 ($r = 0.24$; $P < 0.05$).

Measures
Coping with everyday stress. Active coping and withdrawal were assessed with the German Coping Across Situations Questionnaire (14), consisting of seven potentially stressful domains (parents, peers, leisure time, romantic relationships, self, future, school) and 20 coping strategies. The participants were requested to indicate (either yes or no) which coping strategies they used to deal with a stressor in each of the seven domains. Based on factor analysis (14), each of the 20 coping strategies across all domains could be assigned to one of three coping styles, two of which were used for present purposes. Sample items read "I discuss the problem with my parents" (active coping; 7 items) and "I withdraw because I cannot change anything anyway" (withdrawal; 6 items). Mean scores (ranging between 0 and 7 for active coping and 0 and 6 for withdrawal) indicate the average number of coping strategies used across all domains. Cronbach's α for these two coping dimensions, summed across all domains, ranged from 0.81 to 0.93 and 0.83 to 0.90, respectively, across waves.

Internalizing and externalizing symptoms
The German Youth Self-Report (YSR) (19,20) was used. With a total of 102

items (rated not true, somewhat true, sometimes true, often true, or very often true), the YSR consists of multiple symptoms that can be combined in two broadband scales: internalizing and externalizing symptoms. By collapsing these two scales, a total symptomatology score can be calculated. Norms, reliability, and validity of the YSR are well established (19). Mean sum scores (Table 1) indicate that our participants generally displayed low-to-moderate symptomatology across time outside of the clinical range (1). Cronbach's α for internalizing, externalizing, and total symptomatology across waves ranged from 0.85 to 0.90, 0.75 to 0.84, and 0.91 to 0.94, respectively.

Glycemic control
At each measurement wave, physicians' assessments of A1C values (matched to when the questionnaires were completed and using the same high-performance liquid chromatographic assay across sites) served as a criterion measure for glycemic control. Patients visited their physicians to determine these A1C values and questionnaires were sent to the physicians to obtain these values.

Statistical methods
A total of 83% patients participated at all four time points (91% participated at two and 85% at three time points), and 10.10% of the data at the scale level was missing across time. No significant differences emerged at Time 1 between those who participated at all time points and those who dropped out. To minimize the bias associated with occasional attrition, we used the expectation maximization algorithm to impute missing data. A nonsignificant (ns) Little's (21) Missing Completely At Random test [χ^2 (166) = 16.34, ns] indicated that all missing values could be reliably estimated.

Cross-lagged path analysis was applied from a structural equation modeling approach using Lisrel 8.54. In all models tested, all within-time associations at Times 1–4 and all autoregressive coefficients were included. Consequently, we looked at directional paths across time when controlling for all within-time associations and rank-order stability. We used standard model fit indexes. The Satorra-Bentler scaled (SBS) χ^2 index should be as small as possible; the root mean square error of approximation (RMSEA) should be less than 0.08; and the comparative fit index (CFI) should exceed 0.90 and preferably 0.95.

Table 1—*Mean-level changes (SD) across time in the study variables*

Variable	Time 1	Time 2	Time 3	Time 4	F (3,105)	η^2
Active coping						
Total sample (N =109)	2.17 (1.33)	3.36 (1.22)	3.30 (1.31)	3.37 (1.33)	27.03***	0.44
Boys (n = 58)	1.91 (1.21)	3.26 (1.28)	3.13 (1.33)	3.20 (1.31)	0.53†	0.01
Girls (n = 51)	2.46 (1.33)	3.46 (1.16)	3.48 (1.28)	3.56 (1.29)		
Withdrawal						
Total sample	1.00 (0.91)	1.27 (1.02)	1.18 (1.01)	1.17 (0.96)	2.36	0.07
Boys	0.85 (0.78)	1.42 (1.01)	1.27 (0.94)	1.14 (0.85)	4.01†**	0.10
Girls	1.17 (1.02)	1.11 (1.01)	1.08 (1.09)	1.20 (1.07)		
A1C (%)						
Total sample	7.85 (2.41)	7.73 (1.92)	8.30 (1.55)	8.26 (1.66)	3.66*	0.10
Boys	7.76 (1.91)	7.79 (1.68)	8.20 (1.29)	8.18 (1.37)	0.41†	0.01
Girls	7.96 (3.09)	7.65 (2.17)	8.41 (1.80)	8.36 (1.94)		
Total symptomatology (raw score)						
Total sample	35.23 (16.82)	33.86 (17.95)	33.32 (18.57)	30.79 (16.73)	3.65*	0.09
Boys	33.95 (14.95)	34.23 (16.01)	33.09 (18.12)	29.20 (19.84)	1.36†	0.04
Girls	36.68 (18.77)	33.45 (20.09)	33.57 (19.25)	32.60 (18.27)		
Internalizing symptoms						
Total sample	11.93 (7.09)	10.75 (7.39)	10.76 (7.54)	10.25 (6.59)	2.77*	0.07
Boys	11.07 (6.21)	10.17 (6.87)	10.17 (7.77)	9.13 (5.91)	0.60†	0.02
Girls	12.92 (7.92)	11.51 (7.99)	11.53 (7.51)	11.68 (7.13)		
Externalizing symptoms						
Total sample	11.00 (5.15)	11.25 (5.55)	10.94 (5.80)	9.77 (5.35)	5.21**	0.13
Boys	11.16 (5.07)	11.73 (5.90)	11.63 (5.91)	9.99 (4.99)	0.62†	0.02
Girls	10.82 (5.28)	10.67 (5.11)	10.12 (5.60)	9.43 (5.73)		

SD is within parentheses. Total, externalizing, and internalizing symptoms are reported as raw scores. †Represents the F-value for the interaction-term with gender. *$P < 0.05$. **$P < 0.01$. ***$P < 0.001$.

RESULTS

Preliminary mean-level analyses
Table 1 presents all mean values at Times 1–4. A series of ANOVAs revealed limited sex differences with girls scoring higher than boys on active coping at Time 1 (F [1,108] = 4.90, $P < 0.05$, $\eta^2 = 0.04$) and on internalizing symptoms at Time 4 (F [1,108] = 4.15, $P < 0.05$, $\eta^2 = 0.04$). Repeated-measures ANOVAs with sex as a between-subjects variable indicated that, for the total sample, active coping and A1C levels increased across time whereas symptomatology decreased across time. Mean-level changes were moderated by sex (but not by age, illness duration, and level of paternal education). Whereas girls showed virtually no change across time in withdrawal, boys showed a quadratic trend with initial increases followed by later decreases.

Cross-lagged path analyses
The baseline model included all within-time associations and stability coefficients [SBSχ^2 (84) = 150.26 ($P < 0.001$); RMSEA = 0.09; CFI = 0.91]. Next, we included cross-lagged paths from coping to symptoms and A1C, from symptoms to coping and A1C, and from A1C to coping and symptoms, resulting in a model with an acceptable fit [SBSχ^2 (54) = 101.35 ($P < 0.001$); RMSEA = 0.09; CFI = 0.94] and a significantly better fit than the baseline model [ΔSBSχ^2 (30) = 49.87, $P < 0.05$]. A total of eight cross-lagged paths were significant at $P < 0.10$. All the remaining cross-lagged paths were trimmed and resulted in the final model [SBSχ^2 (76) = 110.81 ($P < 0.01$); RMSEA = 0.07; CFI = 0.94], which had a comparable fit to the previous, less parsimonious model [ΔSBSχ^2 (22) = 13.85, $P = 0.91$].

Figure 1 presents all standardized stability and cross-lagged coefficients from this final model (see Table 2 for within-time associations). Total symptomatology at Times 1 and 2 positively predicted withdrawal at Times 2 and 3, respectively. Active coping at Time 1 negatively predicted A1C levels at Time 2, which, in turn, negatively predicted active coping at Time 3. A1C levels at Times 1 and 3 positively predicted withdrawal at Times 2 and 4, respectively. Further, withdrawal at Time 2, in turn, positively predicted total symptomatology at Time 3, which

again positively predicted A1C levels at Time 4. The total effects from A1C levels and psychological symptoms at Time 1 to A1C levels at Time 4 reached significance ($z = 1.87$, $P < 0.10$; and $z = 2.39$, $P < 0.05$, respectively).

Next, a multigroup analysis was performed in which we compared a constrained model (with all eight significant cross-lagged paths set as equal across sex) against an unconstrained model (with these cross-lagged paths allowed to vary across sex). No significant difference emerged between both models (ΔSBSχ^2 [8] = 8.07, $P = 0.43$) and, hence, the more parsimonious constrained model was favored, indicating that the final model fitted equally well for boys and girls.

Finally, we investigated whether the final cross-lagged model could be replicated for internalizing and externalizing symptoms. In the case of internalizing symptoms [SBSχ^2 (77) = 105.39 ($P < 0.05$); RMSEA = 0.06; CFI = 0.95], similar results were obtained as can be seen in Figure 1, except that the path from internalizing symptoms at Time 1 to withdrawal at Time 2 failed to reach significance. In the case of externalizing symptoms [SBSχ^2 (77) = 118.96 ($P <$
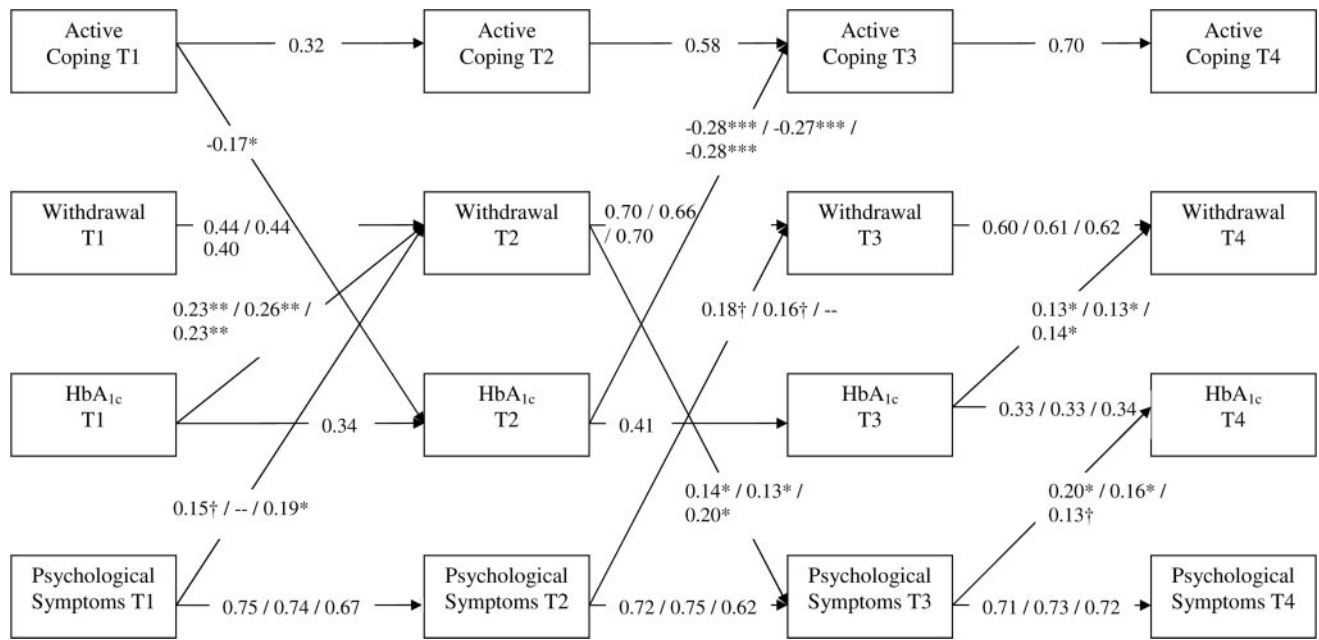
Figure 1—*Final cross-lagged path model linking coping, symptomatology, and A1C. The first coefficient is for the model with total symptomatology, the second coefficient for internalizing symptoms, and the third coefficient for externalizing symptoms. When the value is identical for the three models, only one coefficient is provided. Within-time correlations are not presented for reasons of clarity. All path coefficients are standardized and all stability coefficients are significant at P < 0.001; †P < 0.10; *P < 0.05; **P < 0.01; ***P < 0.001.*

0.01); RMSEA = 0.07; CFI = 0.92], similar results were again obtained except that the path from externalizing symptoms at Time 2 to withdrawal at Time 3 failed to reach significance.

CONCLUSIONS — The purpose of the present study was to analyze the longitudinal associations between glycemic control, coping, and psychological symptoms in adolescents with type 1 diabetes. First, active coping was found to increase over time, which was consistent with the findings on community adolescent samples (13). The less adaptive coping style, withdrawal, was applied much less frequently. Further, whereas girls stayed rather stable across time in their use of withdrawal, boys initially increased their use of withdrawal followed by later decreases. Paralleling this increased use of active coping strategies across time, psychological symptoms tended to decrease across time. In accordance with previous studies, glycemic control tended to worsen over time, pointing to the difficulties many adolescents experience in achieving good glycemic control, which is probably due in part to hormonal changes associated with the teenage years. Other developmental tasks, such as an increased involvement with peers combined with a growing independence from parents, may distract from adhering to the medical regimen (11,18).

Second, as hypothesized, the longitudinal findings pointed to a detrimental vicious circle operating across time. A worsening of glycemic control and psychological symptoms at Time 1 were associated with increases in withdrawal at Time 2, which, in turn, was associated with an increase of symptomatology at Time 3. Symptomatology at Time 3 again was associated with a worsening of glycemic control at Time 4. Apparently, suboptimal levels of glycemic control and the presence of psychological symptoms early in adolescence could set in motion a chain of events or mechanisms leading to poor glycemic control several years later. Improving active coping strategies through intervention efforts could help to interrupt this chain of events (22). Active coping at Time 1 was associated with better glycemic control at Time 2, which, in turn, was associated with increases in active coping at Time 3, pointing to an important reciprocal mechanism. Good glycemic control, in turn, was associated with decreases in withdrawal coping across time (i.e., from Time 1 to Time 2 and from Time 3 to Time 4). Apparently, active coping could have protective functions by lowering A1C values 1 year later, whereas obtaining adequate levels of glycemic control seemed to protect against the use of withdrawal coping.

In sum, whereas several longitudinal findings tended to be replicated across

time (such as poor glycemic control and psychological symptoms influencing withdrawal), other longitudinal mechanisms were found to operate at specific periods in time. A first explanation could be our relatively small sample size, which decreased the power of the statistical tests. A second explanation might be that these mechanisms become somewhat apparent depending on the adolescent's developmental stage. Active coping was a stronger predictor of glycemic control when the participants were younger, whereas psychological symptoms were a stronger predictor of glycemic control at the end of the study. With respect to the latter, as adolescents become older, they are increasingly responsible for their illness management. During this process, internalizing and externalizing symptoms may adversely affect glycemic control partially due to their negative impact on self-management and self-care behaviors. They point to important mechanisms that could be addressed in clinical settings provided that the obtained findings are scrutinized and replicated in future studies. A regular screening of maladaptive coping strategies and for providing education or training in optimizing the use of active, problem-focused coping to maintain adequate levels of glycemic control might be warranted in adolescents with diabetes.

The findings for the overall symptomatology score were quite similar to those

Table 2—Correlations among the study variables

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. AC T1	0.31***	0.39***	0.35***	0.38***	0.03	−0.03	0.01	0.10	0.05	0.10	0.11	−0.14	−0.22*	−0.22*	−0.12
2. AC T2		0.52***	0.58***	0.04	0.01	−0.20*	−0.04	0.02	−0.06	−0.05	−0.07	−0.14	−0.01	0.08	0.03
3. AC T3			0.68***	0.01	−0.07	0.05	−0.05	0.01	0.00	0.04	−0.03	−0.13	−0.30**	−0.11	0.05
4. AC T4				0.12	0.02	0.11	0.08	0.04	0.06	0.11	0.07	−0.12	−0.16†	−0.11	0.08
5. W T1					0.42***	0.35***	0.40***	0.45***	0.32***	0.36***	0.32***	−0.06	−0.01	−0.14	−0.10
6. W T2						0.70***	0.59***	0.33***	0.41***	0.43***	0.45***	0.23*	0.16†	0.10	−0.06
7. W T3							0.65***	0.29**	0.45***	0.55***	0.49***	0.19*	0.09	0.09	0.02
8. W T4								0.33***	0.51***	0.45***	0.54***	0.08	0.08	0.18*	−0.04
9. TS T1									0.77***	0.62***	0.63***	0.08	0.03	−0.05	0.12
10. TS T2										0.80***	0.73***	0.11	0.07	0.03	0.13
11. TS T3											0.75***	0.14	0.15	0.08	0.21*
12. TS T4												0.07	0.08	0.06	0.17†
13. A1C T1													0.36***	0.05	0.04
14. A1C T2														0.41***	0.28**
15. A1C T3															0.35***
16. A1C T4															—

AC, active coping; W, withdrawal; TS, total symptomatology; A1C, glycemic control; T, time. †$P < 0.10$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

found in separate analyses for internalizing or externalizing symptoms. Although "externalizing" and "internalizing" describe a basic distinction in symptomatology that is extensively validated (23), these two types of symptoms often co-occur in adolescence. Our separate analyses on internalizing and externalizing symptoms indeed demonstrated that comparable time-dependent mechanisms occurred. It should be noted that, for most participants, the magnitude of psychological symptoms did not meet the threshold for being labeled as psychopathology. However, the fact that these symptom scores represented rather normal variants does not downgrade the importance of our findings. Apparently, intraindividual changes in psychological symptoms outside the clinical range also have the potential to influence variables such as glycemic control. In addition, subclinical levels of psychological symptoms could hinder adolescents from mastering normative developmental tasks and render them more vulnerable for developing psychopathology later in life (24).

To conclude, partially due to our small sample size, we found limited sex differences. Future studies using larger samples should separate newly diagnosed adolescents from those who have established diabetes given that the impact of the study variables could possibly vary depending on illness duration. Despite these limitations, the present study demonstrated that adolescents with diabetes should be routinely screened for psychological symptoms (and changes therein) and for the extent to which they make use of adaptive or maladaptive coping strategies, not only in dealing with diabetes but also with normative, everyday stressors (11,25).

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